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Editorial

Traditionally all abstracts of contributions submitted to the 22nd General Assembly are included free of charge in the *Abstract Book* once they were accepted by the appropriate convener(s) and once they were received by February 1997, i.e., about two months *after* the deadline, and in the standard format and of sufficient quality for reproduction. Abstracts submitted for symposia sponsored by two Sections included in different parts of the *Abstract Book* are included (twice) in both parts, respectively.

Like in previous years, not all contributions included will actually be presented. Because of the lack of financial support, several young scientists as well as colleagues from the central and east-European countries will not be able to participate in the meeting, although the Society has continued its support schemes, such as the Young Scientists' Travel Award and the East European Support Award. In this way there are more abstracts included in the *Abstract Book* than contributions compiled in the *Programme Book*. Therefore, in order to simplify the ordering of abstracts within a symposium, we have adopted the alphabetical order with respect to the surname of the first author rather than the order of presentation.

With more than 4.300 contributions received, the *Abstract Book* has become an open forum for fast distribution of results of geophysical research on a pan-European, international level, helping, at the same time, to promote the contact between all geophysicists in Europe. Please, support the fostering of cooperation and contact your colleagues also if not personally present this time.

On behalf of the Society I am very pleased to welcome you to Vienna on the occasion of the 22nd General Assembly of the European Geophysical Society. May your participation in this meeting be successful and scientifically rewarding.

A.K. Richter
Executive Secretary

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CONTENTS

PART II Hydrology, Oceans & Atmosphere & Nonlinear Geophysics

II.1. HYDROLOGICAL SCIENCES (HS)

II.2. BIOSPHERIC ASPECTS OF THE HYDROLOGICAL CYCLE (BAHC)

SOLAR-TERRESTRIAL SCIENCES (ST)

ST1/OA31 Review session on solar terrestrial relations

Convener: Fabian, P.

THE ROLE OF THE IONOSPHERE IN THE CHAIN OF SOLAR TERRESTRIAL RELATIONS

K. Schlegel (MPI für Aeronomie, Postfach 20, D-37189 Katlenburg-Lindau, Germany)

The energy flow of solar electromagnetic and particle radiation through the ionosphere is considered. Examples are explained how the energy (in case of particles also their momentum) is transferred to the thermosphere and the middle atmosphere by various processes. Effects of the variability of the solar radiation are also discussed as well als ionospheric forcing from below which is ultimately also caused by solar irradience.
Our present understanding of the relevant processes is summarized and open questions are addressed.

ST2/OA25 Open session on the middle atmosphere

Convener: Dameris, M.
Co-Convener: Krüger, B.C.

AIRCRAFT BASED IMRMS MEASUREMENTS OF ACETONE AND OTHER ORGANIC TRACE GASES IN THE UPPER TROPOSPHERE AND LOWER STRATOSPHERE

F.Arnold, F.Grimm, T.Stilp, V.Bürger, J.Schneider and K.Gollinger
Max Planck Institute (Atmospheric Physics Devision),
Saupfercheckweg 1, 69117 Heidelberg, Germany

Acetone and other organics were measured in the upper troposphere and lower stratosphere during several aircraft campaigns in summer and winter covering latitudes from 30°N to 75°N. Acetone was found to be ubiquitious and to reach large volume mixing ratios (up to 3000 pptV) in extended air masses. Photochemical conversion of acetone leads to HO_2 and peroxyacetyl radicals. The latter in turn form HO_2 as well as PAN and organic acids. Thereby acetone potetially influences various other trace gases and aerosols.

MULTI-ANNUAL SIMULATIONS OF STRATOSPHERIC CONSTITUENTS IN A CLIMATE MODEL

J. Austin (Meteorological Office, London Rd., Bracknell, Berkshire, RG12 2SZ, U.K.) and N. Butchart

Two-year integrations are presented of a climate model with fully coupled and comprehensive stratospheric chemistry. The model has 49 levels between the ground and 0.1 mbar. The constituents are initialised with UARS data and 2-D model fields for January, and the model is integrated for two years. Comparisons are made with UARS monthly mean observations of the long-lived constituents O_3, HNO_3, N_2O_5, HCl, $ClONO_2$, CH_4 and N_2O and with total ozone measurements from TOVS. Preliminary results show that the model results are in reasonable agreement with the UARS data but with some quite important differences in detail. In particular, in agreement with other 3-D model studies, the model HCl values are generally too low, especially in the tropics. On the other hand model ClO values are in reasonable agreement with UARS observations. The early results also demonstrate that although the simulation of total ozone in the southern hemisphere is excellent throughout the year, the simulation of total ozone in the northern hemisphere is poor. The model transport will be investigated in further detail using conserved tracers to diagnose any potential weaknesses in the model meridional circulation.

SIMULATION OF THE WINTER STRATOSPHERE WITH ASSIMILATED TEMPERATURE FIELDS

F. Baier, G. Günther (Institut für Geophysik und Meteorologie, Universität zu Köln, Albertus–Magnus–Platz, D–50923 Köln,Germany)

To study planetary waves during specific episodes (e.g. stratospheric warmings) mechanistic models frequently force geopotential heights derived from observations at the models lower boundary. But even when model initialization is perfect and radiation can be neglected, simulated fields deviate from observations, because vertical propagating waves interact with background winds. Here we couple a global mechanistic model over a closed altitude range with observations to study the lower stratosphere as a filter and source of wave activity. We use the Newtonian relaxation technique by nudging temperature fields. The main results due to forcing of different model layers (1000-100, 1000-10 and 1000-1 hPa) with daily global data from January, February and March 1989 are: forcing only tropospheric layers is insufficient to prognosticate the stratospheric circulation, while use of data from above 10 hPa gives no significant improvement. We conclude that the condition of the lower stratosphere influences the circulation up to mesospheric levels.

GRAVITY WAVE DIAGNOSIS OF THE GFDL "SKYHI" MODEL USING THE EMPIRICAL NORMAL MODE METHOD

Martin Charron (Department of Atmospheric and Oceanic Sciences, McGill University, Montréal, Québec, Canada)
Gilbert Brunet (Recherche en Prévision Numérique, Environnement Canada, Dorval, Québec, Canada)

The importance of gravity wave forcing on the zonal mean state of the middle atmosphere has been recognized during the last two decades. In order to better understand and to quantify the specific role of gravity waves on the climatology of the stratosphere and mesosphere (and thus to be able to formulate dynamically significant gravity wave drag parameterization schemes), it is crucial to develop tools which can isolate gravity wave processes. In the present study, we propose a diagnostic method which uses pseudo-energy conservation to extract almost balanced quasi-monochromatic gravity and inertio-gravity wave modes (called Empirical Normal Modes) from meteorological fields. The analytical framework will be briefly presented, as well as some results obtained by applying the aforementioned method on the output of the GFDL "SKYHI" Troposphere-Stratosphere-Mesosphere General Circulation model (resolution of $1° \times 1.2°$) with no subgrid scale gravity wave drag parameterization. The analysis shows that gravity wave coherent structures emerge mainly just above the tropopause, and that a possible link between the breaking level of the waves and an imposed vertical mixing scheme based on a low Richardson number in the "SKYHI" model might exist.

STRATOSPHERIC VACILLATIONS IN A GENERAL CIRCULATION MODEL

Bo Christiansen and A. Guldberg (Danish Meteorological Institute)

To study the variability in the winter stratosphere we have performed a series of perpetual January experiments with Arpege, the French community general circulation model.
On the winter hemisphere temperature anomalies develop in the mesosphere and slowly descend through the stratosphere until they dissipate in the lower stratosphere. The variability is oscillatory with a time scale of about 50-100 days and show a vertical dipole structure: a warm lower stratosphere coincides with a cold upper stratosphere. Positive or weak negative values of the Eliassen-Palm flux correlates with accelerations of the zonal wind, inferring that the warmings are driven by interactions between the zonal mean and resolved eddies.
Variability on this time scale is not apparent in the troposphere. To assess the influence of tropospheric transience we have performed experiments with time independent tropospheres with different strength of the eddies. Although the transient wave forcing from the troposphere is absent vacillations persist in the stratosphere with unchanged time scale. Preliminary results indicate the existence of a critical wave forcing at the tropopause level which has to be surpassed for oscillations to exist. Furthermore, the time scale of the oscillations decreases with increasing wave forcing.
The behaviour described above resembles closely the behavior of the simple model of the stratospheric dynamics introduced by Holton and Mass.

TWO-COLOR LIDAR OBSERVATION OF A NOCTILUCENT CLOUD AT ALOMAR

G. von Cossart (Institut für Atmosphärenphysik an der Universität Rostock, Germany)
U.-P. Hoppe (Norwegian Defence Research Establishment, Kjeller, Norway)

Two lidars, located in the ALOMAR observatory (69.3°N, 16.0°E) near Andenes/Norway, made simultaneous and common-volume measurements of an overhead noctilucent cloud (NLC) layer during the midnight period of August 12/13, 1995. The Rayleigh lidar and the ozone lidar provided measurements at wavelengths of 532 nm and 308 nm, respectively. During the observation time from 23:40 UT to 01:30 UT and 23:55 UT to 01:33 UT maximum backscatter ratios of 56 and 28 have been obtained for 532 and 308 nm, respectively. In the NLC layer, the ratio of volume backscatter coefficients ß(308)/ß(532) increased from 4.3 to 5.1 for altitudes from 81.8 km to 83.6 km. Applying standard Mie-theory and assuming a lognormal particle size distribution, these ratios imply modal radii of the NLC particles between 15 nm and 45 nm for values of the distribution width between 1.2 and 1.6 near 82.7 km altitude, with somewhat smaller particles above and larger particles below

INFLUENCE OF THE QUASI-BIENNIAL OSCILLATION ON THE EVOLUTION OF TRACER FIELDS IN THE EQUATORIAL STRATOSPHERE

W. Choi (Dept. Atmospheric Sci., Seoul Nat. University, Seoul, Korea)
W.B. Grant, J. H. Park (NASA Langley Research Center), K.-M. Lee (Kyungpook Nat. University, Taegu, Korea), H. Lee (Seoul Nat. University)

Stratospheric aerosol data as well as HF and CH_4 obtained by the HALOE instrument on the UARS satellite indicated that transport from the tropical stratospheric reservoir to midlatitudes is strongly dependent on the equatorial QBO. The time-latitude sections of normalized aerosol, HF and CH_4 show clear sign of sinking at the equator with time. The equatorially-asymmetric distribution of aerosol reveals the interannual variability of annual oscillation in the subtropics. The meridional divergence and convergence related with the equatorial rising/sinking motion seems to be crucial in influencing this variability. At the equator the vertical convergence (divergence) points were located in HF and CH_4 fields and compared with points of maximum westerly (easterly). The divergence points are especially in good agreement with the points of easterly maxima which is another evidence of role of the secondary meridional circulation in equatorial transport.

Vertical Propagation of Rossby and Kelvin Waves in Stratosphere

Cristiana Ciuperca, Sabina Stefan
University of Bucharest, Faculty of Physics

The stratosphere is dynamically very different from the underlying troposphere. Baroclinic instability is virtually suppressed and disturbances are mainly forced from below. The stratification of the stratosphere acts as a filter removing the smaller scale disturbances and allowing only the longest waves to propagate out of the troposphere to great heights in the stratosphere. These waves with upward propagation may influence the flow at the great heights and the transport processes and so the advection of ozone that is very important in generating concentration anomalies. An upward propagation wave and interaction with zonal flow determine the quasi-biennial oscillation (QBO), too. This paper has discribed the behavior of the vertically propagating Kelvin and Rossby waves, trying to explain the connection between troposphere and stratosphere circulation . The amplitude and the dependence of the vertical velocities of the latitude are different for the Kelvin and Rossby waves and so these waves are internally connected to their interaction with the basic zonal state. The distribution of the vertical velocities is consistent with the currently accepted theories of the mechanism that excite the QBO: the flow is forced from the troposphere and that it involves interaction between upward propagating waves and the mean flow. In addition, the values of the vertical perturbation of velocities confirm idea that in equatorial stratosphere the vertically propagating Kelvin and Rossby waves can carry important fluxes of heat and momentum.

MID-LATITUDE NOCTILUCENT CLOUD OBSERVATIONS BY LIDAR

G. von Cossart, J. Höffner, P. Hoffmann (Institut für Atmosphärenphysik an der Universität Rostock, Germany)
P. Keckhut (Service d'Aeronomie du CNRS, Verrieres, France)

Regular zenith-directed Rayleigh lidar soundings at Juliusruh (54.63°N, 13.38°E) in summer 1995 and 1996 indicated the presence of overhead noctilucent clouds (NLC) during four nights in June. For three of these nights, NLC were also sighted visually near the northern horizon. For one of the lidar-observed NLC events in 1995, temperature profiles were obtained immediately prior to the appearance of the NLC. These observations show at 81 km a strong cooling of about 30 K within two hours. The wind velocity and direction during the NLC events were inferred from daytime common-volume MF radar wind measure-ments. During the occurrence of the NLCs in 1995 the interpolated MF radar wind was south-westwards directed with velocities between 9 - 32 m/s. In July 1996 another overhead NLC was recorded by a zenith-directed lidar at 770 nm combined with a visual observation near the northern horizon at Kühlungsborn (54.12°N, 11.77°E). Different from high latitudes, NLCs at mid-latitudes can be observed by lidar in total darkness. Therefore, mid-latitude observations have the advantage to allow a characterisation of NLC particle size distributions and particle densities even with comparatively simple, multi-color lidars.

CORRELATIONS OF STRATOSPHERIC O_3 AND N_2O OVER THE SOUTH POLE FOR TWO QUASI-ANNUAL CYLES

S. Crewell (Meteorological Institute, University of Bonn, Germany)
D. Cheng, R. L. de Zafra (Department of Physics and Institute for Terrestrial and Planetary Atmospheres, State University of New York, Stony Brook, NY)
U. Klein (Institute for Environmental Physics, University of Bremen, Germany)
R. A. Chamberlin (Department of Astronomy, Boston University, Boston, MA)

Millimeter wave spectroscopic measurements of stratospheric O_3 and N_2O over the South Pole have been performed for two 11-month periods: (1) February 1993-January 1994 and (2) January-December 1995. Strong similarities exist between the two quasi-annual cycles for both O_3 and N_2O. A double-peaked profile dominates O_3 vertical distribution in both years. N_2O observations show similar atmospheric descent rates during fall and winter. During springtime warmings, the O_3/N_2O ratio shows a tight coupling between O_3 and N_2O around 20 km, as transport creates the low altitude O_3 peak. A rapid and systematic decrease of the O_3/N_2O ratio during summer in the 25-30 km region (while N_2O is essentially stable) supports the increasingly dominant role of photochemistry in producing the vertical profile for O_3 above ~ 25 km while leaving a transport-produced layer with a relatively large mixing ratio below ~ 25 km. The resulting double-peaked O_3 distribution, which persists for many months, can alter the normally negative correlations between O_3 and N_2O in the lower and mid stratosphere, although in measurements of the N_2O/O_3 ratios for polar air, these perturbations have often been taken to be a hallmark of catalytic ozone depletion by chlorine.

OBSERVATIONS OF INTRASEASONAL OSCILLATIONS IN THE HIGH-ATITUDE AIRGLOW

P.J. Espy and J. Stegman (Department of Meteorology, Stockholm University, S-106 91 Stockholm, Sweden)

Observations of fluctuations in the night-airglow emissions from excited hydroxyl (OH), molecular oxygen (O2) and atomic oxygen (OI) have been used to infer the parameters of gravity, tidal and planetary-wave oscillations near the mesopause by many authors. In this study, the near-infrared (1000-1600 nm) Meinel bands of OH were observed along with the 762 nm Atmospheric band of O2 and the 557.7 nm green line of OI from a ground-based observatory outside of Stockholm, Sweden (59.5N, 18.2E). The nightly averaged OH temperature, as well as the nightly averaged radiance of the OH, O2 and OI emissions, all show clear evidence of distinct oscillations in the 60-70 day period range. In addition, the phase of the OH oscillations are nearly 90 out of phase with those displayed by the O2 and OI emissions. We will present the analysis, identification and seasonal evolution of these oscillations. In addition, we will suggest possible mechanisms for the generation of these high-latitude oscillations, which are strikingly similar to those seen in the equatorial mesospheric and lower thermospheric wind field.

WAVE STRUCTURE AND CORRELATION OF THE THERMODYNAMICAL PROCESSES IN THE MIDDLE AND LOWER ATMOSPHERE

Fahrutdinova A.N., Gurianov V.V., Yasnitsky D.S., Kulikov V.V., Solntsev R.N. (Kazan State University, Kremlevskaya Str. 18, Kazan 420008, Russia)

It is studying in the paper the problem of correlation of thermodynamical processes in the middle atmosphere. We have used as an initial data the simultaneous mean-daily values of thermodynamical parameters, measured in the Kazan University by the methods of temperature (troposphere, including tropopause) and meteor (upper mesosphere - lower thermosphere) sounding during the main and transition seasons of 1994 year.
Based on the analysis of the thermodynamical parameters temporal variations in the troposphere, tropopause and in the height region of upper mesosphere - lower thermosphere, there were revealed coherent structures of the wave disturbances in the spectrum's interval corresponding to the planetary waves time scales. This structures are displaying the height and seasonal dependence. It was founded the active influence of the tropopause and mesopause on the coherence of analysed wave structures.

AN ESTIMATE OF THE QBO IN WATER VAPOR CONCENTRATION AND TRANSPORT IN THE QBO DOMAIN IN GCM EXPERIMENTS

Marco A. Giorgetta, Max-Planck-Institut für Meteorologie

In order to study the relationship between the QBO and the general circulation, GCM experiments have been performed, using the ECHAM4 T42-L19 model, where the QBO was assimilated by a linear relaxation technique. The QBO modifies firstly the temperature above the tropical tropopause, hence also the water vapour content that may pass the tropopause, and secondly the vertical transport velocity by the secondary meridional circulation. Thus the upward transport is about 0.08 mm/s slower during westerly QBO-phase than during the opposite phase. The QBO signal found in the specific humidity on 50 hPa at the equator has an amplitude of 0.04 ppmm which is about half of the signal caused by ENSO in this model. The strength of the QBO signal is limited by the time scale of the QBO because the equilibration of the specific humidity has a much longer timescale. The combination of QBO and ENSO creates low frequency variability. The results are limited by the low vertical resolution and the neglect of photochemical processes.

MIDLATITUDINAL LOWER IONOSPHERE DISTURBANCES CAUSED BY NATURAL SOURSES

Gokov A.M., Tyrnov O.F. Kharkiv State University, Kharkiv, Ukraine

There are given experimental data on natural disturbances (powerful earthquakes, the solar terminator, strong thunderstorms, solar flares and magnetic storms) having effects on the midlatitudinal ionospheric D-region parameters, characteristics of partially reflected (PR) signals and radio noise at f= 2-4 MHz. There are investigated parameters of the wave disturbances (a character, type, periods, durations and velocities) arising over these periods in the D-region. Our investigations were carried out by a PR technique within 1977-1994. The measurements of PR signals and radio noise were made under different heliogeophysical conditions ; the observation durations being minutes-hours-days; ~200 samples covering each source of the disturbances.

ELECTRON COLLISION FREQUENCY VARIATIONS IN THE LOWER IONOSPHERIC D REGION DURING MAGNETIC STORM

Gokov A.M., Tyrnov O.F. Kharkiv State University, Kharkiv, Ukraine

Using a partial reflection technique it was found increasing of the electron collision frequency by more than 50% at the lower ionospheric D-region (Z<70 km) at the time of precipitating charged particles during magnetic storms. Our observations have been made during 3 magnetic storms in 1984-1985 in the vicinity of Kharkiv. The precipitation of charged particles was observed during 3-7 days after the magnetic storms. At these events there were observed intensive partially-reflected signals from the heights of 55 <Z< 70 km. It was found the electron density to become several times larger. The paper presents calculations of flow intensities of precipitating charged particles and ion-production velocities, made for these heights.

NUMERICAL EXPERIMENTS IN STRATOSPHERIC DYNAMICS

A.R.Gregory (Department of Meteorology, University of Reading. 2 Earley Gate, Whiteknights, PO Box 239, Reading. RG6 6AU, UK)

The dynamical stratosphere can be modelled by the primitive equations with a suitable radiation scheme and an idealised forcing near 100mb (the latter representing tropospheric disturbances). Such a model has been written using isentropic coordinates and potential vorticity as a prognostic variable, making it ideal for the study of dynamics. Experiments have been carried out in perpetual January conditions with an initially zonally symmetric stratosphere. Various amplitudes of wave one forcing have been applied to the winter hemisphere. In all cases, except for low amplitude forcing, there is an initial erosion of the polar vortex before a quasi-periodic regime is entered. This regime consists of the formation of a series of anticyclones and their eastward advection around the polar vortex to a prefered location. These anticyclones decay but sometimes a low resolution vortex merger occurs between successive anticyclones. Similar behaviour has been observed in the real stratosphere during sudden warmings. It is interesting that the model continues the quasi-periodic regime for the duration of the model run, hundreds of days after the lower boundary forcing became steady. Results from further experiments with a full seasonal cycle will also be presented.

ON THE SPECTRAL DECOMPOSITION OF STRATOSPHERIC FIELDS

T. Halenka and **T. Halenka** (Department of Meteorology and Environment Protection, Faculty of Mathematics and Physics, Charles University, V Holesovickach 2, Prague, Czech Republic)
P. Mlch (Institute of Atmospheric Physics, Prague, Czech Republic)

Spherical harmonics are used as a basis for the decomposition of stratospheric geopotential and temperature fields. The last twenty years period from 1976 to 1996 is analysed both on the monthly and daily values on 200, 100, 50, 30, 10 hPa levels. The aim of the study is to compare the changes of the principal wave components with respect to the changes of some circlulation patterns (global circulation indices). Special attention is given to the interannual variability with special emphasis to the QBO, ENSO, solar cycles, volcanic activity etc. as well as to the analysis of annual course changes.

GROUNDBASED MICROWAVE DETECTION OF WATER VAPOUR AND OZON AT 51°N

P. Hartogh and C. Jarchow (Max-Planck-Institut für Aeronomie, Postfach 20, D-37189 Katlenburg-Li ndau, Germany)

Groundbased microwave spectroscopy is well suited for monitoring of the vertical distribution of middle atmospheric trace gases in that it provides accurate spectra of the molecular microwave emission. Due to its pressure broadening it is possible to deconvolve the spectra into components of different widths and thereby to obtain mixing ratios as a function of pressure, which can be mapped on an altitude scale. Two microwave spectrometers have been developed at the MPAE and provide data of middle atmospheric water vap our and ozone since 1992. This first simultaneous long term local detection of w ater vapour and ozone gives information about the seasonal variablilty as well a s the interdependence of both gases. A system description will be given and results of the data analysis will be presented.

SIMULATION OF THE DYNAMICS AND CHEMISTRY OF THE POLAR VORTEX DURING THE WINTER 1995/96

G. Günther and F. Baier (Institut für Geophysik und Meteorologie der Universität zu Köln, 50923 Köln, Albertus-Magnus-Platz, Germany)

In the winter 1995/96 temperatures below 195 K, the conventional threshold value for PSC-I formation, were observed in the lower stratosphere between mid December and the begin of March. The low temperatures were caused by tropospheric anticyclones, which are usually accompanied by a high cold tropopause and low ozone values in the lower stratosphere. The combined effect of dynamics (elevated tropopause and advection of ozone poor air) and chemistry (chlorine activation due to heterogeneous chemistry taking place on the surface of PSC's) led to the evolution of minima in total ozon, the so called mini-holes. The strongest ozone destruction with total ozone values near 200 DU was observed in March over northwestern europe.
The aim of this study is to investigate the dynamical and chemical processes and their interaction during this episode. A threedimensional mechanistic model of the middle atmosphere covering the altitude range from 0 to 150 km, which is coupled with a chemistry and a transport module, is used to simulate the period from December 95 to April 96. The data for the temperature field, used to force the model at the lower boundary region are taken from ECMWF analyses. The main results will be presented and compared to data derived from satellite measurements.

DEVIATIONS BETWEEN DIFFERENT METHODS FOR THE DETERMINATION OF THE AGE OF STRATOSPHERIC AIR AS CONSTRAINT FOR MIXING INTO THE POLAR VORTEX

J. Harnisch, R. Borchers (Max-Planck-Institut für Aeronomie, Postfach 20, 37189 Katlenburg-Lindau, Germany)
W.Bischof (Styrmansvagen 13 - B119, 18492 Akersberga , Sweden)
M. Maiss (Max-Planck-Institut für Chemie, Joh.-J.-Becher-Weg 27, 55128 Mainz, Germany)

The age of stratospheric air is determined through measurements of the mixing-ratio of a trace component with a long atmospheric lifetime and a well known increase in the troposphere. Species like CO_2, SF_6, CF_4, C_2ClF_5 and C_2F_6 have been used for this purpose and are expected to yield consistent results. For the mid-latitudes this appears to be the case. At altitudes above 20 km inside the arctic polar vortex we find significantly higher ages for the perfluorinated compounds than for CO_2. We present evidence that these inferred differences in age are not due to destruction of perhalogenated substances in the upper stratosphere but result from the mixing in of CO_2-rich air into the vortex. Our data from the EASOE-winter 1991/92 can be used as a new constraint for exchange processes through the walls of the vortex.

PARAMETERIZATION OF WAVE BREAKING IN A LINEAR MODEL OF STATIONARY PLANETARY WAVES IN THE STRATOSPHERE

Ch.Hauck and V.Wirth (Meteorologisches Institut, Universität München, Theresienstr.37, D-80333 München, Germany)

Linear Theory has proven sucessful in modeling the vertical and meridional propagation of stationary planetary waves in the stratosphere. Usually, in such models wave dissipation is implemented as Newtonian cooling and Rayleigh friction. Here we make use of a recently developed parameterization for planetary wave breaking (Garcia, 1991) in order to obtain an improved representation of wave dissipation in the neighborhood of critical lines. Although we keep the zonal mean basic state fixed, solving for the wave turns into a nonlinear problem, as the dissipation coefficient depends on the wave itself. The problem is solved iteratively. In contrast to the wave amplitude, the Eliassen-Palm flux divergence depends rather sensitively on the wave breaking parameterization. It is expected that the EP-flux divergence thus generated results in a new tool to diagnose the occurence of strong wave-mean flow interaction from the zonal mean basic state. As a test of its usefulness, the model is applied to various basic states which are known to enhance or suppress major stratospheric warmings.

INTERANNUAL VARIABILITY IN EQUATORIAL LOWER STRATOSPHERIC WATER VAPOUR AS OBSERVED BY HALOE

D.R Jackson and J.E Harries (Space and Atmospheric Physics, The Blackett Laboratory. Imperial College, London, UK)

The Halogen Occultation Experiment (HALOE), which flies on the Upper Atmosphere Research Satellite (UARS), has been operational for over five years and provides an excellent means of examining water vapour and other constituents in the middle atmosphere. The observational range of the HALOE water vapour channel extends down to approximately the tropopause. Since the water vapour that enters the lower tropical stratosphere from the troposphere is strongly influenced by the tropopause temperature, these observations provide information about the global structure and behaviour of the tropical tropopause. In a previous paper (Jackson et al (1996), submitted to Quart. J. Roy. Meteor. Soc.) three years of HALOE data were used to calculate multi-year seasonal averages of water vapour at levels close to the tropopause. In addition, the interannual variability of the water vapour distribution was discussed. Here, we extend this study of interannual variability using the more up-to-date HALOE observations that have subsequently become available, with particular attention being paid to the equatorial Indian and Pacific Ocean regions in boreal winter.

MESOPAUSE WINDS OVER CENTRAL EUROPE IN 1994 AND 1995 AS MEASURED WITH TOTAL AND PARTIAL REFLECTION TECHNIQUES

Jacobi, Ch., Schminder, R. (Institute for Meteorology, University of Leipzig, D-04103 Leipzig, Germany)
Kürschner, D. (Institute for Geophysics and Geology, University of Leipzig, D-04103 Leipzig, Germany)
Singer, W., Hoffmann, P., Keuer, D. (Institute of Atmospheric Physics, D-18225 Kühlungsborn, Germany)

To obtain continuous measurements of the upper mesosphere and lower thermosphere wind field over Central Europe, daily D1 LF wind measurements using commercial radio transmitters (on 177, 225 and 270 kHz) at the Collm Observatory of the University of Leipzig, and MF radar wind measurements on 3.18 MHz at the Juliusruh Station of the Institute of Atmospheric Physics are carried out. These observations, applying to a mean reflection point at 52° N, 15°E, provide the prevailing wind and the tidal wind components and are useful for investigations of the upper atmosphere climatology. Vertical profiles of the wind field parameters can be derived with the aid of combined wind and reflection height measurements. Here height-time cross-sections of half-monthly mean prevailing winds and the semidiurnal tidal wind components using the combined total and partial reflection wind measurements are given for the years 1994 and 1995.

PLANETARY WAVE ACTIVITY AT THE MESOPAUSE OBTAINED FROM LONG-TERM TOTAL REFLECTION WIND MEASUREMENTS AT COLLM, GERMANY

Jacobi, Ch., Schminder, R. (Institute for Meteorology, University of Leipzig, D-04103 Leipzig, Germany)
Kürschner, D. (Institute for Geophysics and Geology, University of Leipzig, D-04103 Leipzig, Germany)

Upper mesosphere and lower thermosphere wind profiles over Central Europe (52° N, 15°E) has been recorded automatically since 1983 by total reflection wind measurements in the low-frequency range at the Collm Observatory of the University of Leipzig. Daily analyses of the zonal and meridional prevailing wind at the mesopause (~ 95 km height) are investigated with respect to interdiurnal oscillations with periods ranging between 2 and 18 days that, as a first approach, can be regarded as a measure for planetary wave activity. A mean climatology of the years 1983 - 1994 is presented, showing the main patterns of the annual planetary wave activity. Long-period waves (> about 10 days period) are mainly present in winter, while the short-period waves (2-4 days period) are found in summer. Time series of planetary wave activity show a significant increase during the period regarded.

THE INTERACTION OF PLANETARY WAVES AND THE ZONAL MEAN CIRCUALTION IN THE LOWER STRATOSPHERE

M.N. Juckes (Meteorologisches Institut der Universität München)

The dissipation of planetary waves in the stratosphere transports heat polewards and maintains the temperature above radiative equillibrium. Observational evidence shows that the majority of the wave activity is dissipated in the lower stratosphere where wave amplitudes are generally small and the dominant dissipation mechanism appears to be radiative damping. For a given wave forcing it is possible to derive the heating rate and hence an estimate of the mean meridional mass circulation. The wave propagation, and hence dissipation, depends on the mean wind profile and hence on the temperature structure. The non-linearity of the wave motions in the upper stratosphere make a full discussion of the interdepence of wave-propagation and changes in temperature structure extremely complicated. In the lower stratosphere, however, the wave amplitude is small and the propagation is dominated by the vertical component. This allows the essential characteristics of the dynamics to be described by a one-dimensional linear model. The model is used to investigate the competing influences of wave forcing, generated by a prescribed disturbance at 100mb, and radiative forcing, taken as Newtonian relaxation to a uniform meridional temperature gradient.

A PARTIAL DIFFERENTIAL EQUATION FOR THE ICE PARTICLE SIZE DISTRIBUTION AT THE POLAR SUMMER MESOPAUSE

J. Klostermeyer (Max-Planck-Institut für Aeronomie, D-37189 Katlenburg-Lindau, Germany)

Assuming heterogeneous nucleation on meteoric dust and taking into account the Kelvin effect, a partial differential equation describing the time evolution of the ice particle size distribution in a moving air parcel is derived. The relevant time scales indicate that for radii between 1 and 100 nm, ice particle growth and decay by condensation and evaporation dominate over the effects of dust particle production, ice particle flux divergence and diffusion. Using a dust size distribution similar to that obtained by Hunten et al. (J. Atmos. Sci. *37*, 1312, 1980) as initial condition, solutions for given time variations of the air parcel temperature are computed and discussed.

VERTICAL STRUCTURE OF TEMPERATURE PERIODIC COMPONENTS BETWEEN 30-90 KM AND ITS COMPARISON TO 2-D NUMERICAL MODELLING

A. Krivolutsky, Yu. Koshelkov, B. Kiryushov, P. Vargin
(Central Aerological Observatory,Pervomayskaya 3, 141700 Dolgoprudny,Moscow Region, Russia)
M.-L. Chanin,A. Hauchecorne, Ph. Keckhut (Service d'Aeronomie du CNRS,Verrieres le Buisson Cedex, 91371,France)

Periodogram analysis procedure was used to reveal the character periods and amplitudes of temperature oscillations (lidar data) between 30 - 90 km (1979-93,Provence:44N,6E). Night mean data sets of lidars mesurements were transformed into simultaneous sets after interpolation. The results has shown the existance of wave motions for periods of the waves near by 5-7,10-14,25-30 and 40-50 days in winter and depressed periodic motions for summer. 2-D numerical modelling has revealed the possibility of these waves to penetrate from below during winter conditions.

SIMULATIONS OF THE STRATOSPHERIC FLOW REGIME DURING THE SOUTHERN FINAL WARMING

W. A. Lahoz (CGAM, Department of Meteorology, University of Reading RG6 6BB, UK)
A. O'Neill (CGAM, Department of Meteorology, University of Reading RG6 6BB, UK)
I. MacKenzie (Department of Meteorology, University of Edinburgh, Edinburgh EH9 3JZ, UK)

The UGAMP Stratosphere-Mesosphere Model (USMM) is used to simulate the southern stratosphere final warming and test if changes in the external forcing affect the stratospheric flow regime. It is found that (a) the USMM simulation compares well with UKMO analyses; (b) the geopotential height wave-1 and wave-2 component patterns at 10 hPa, 60°S are sensitive to the nature of the tropospheric forcing in the model. The implications of these results on our understanding of the different mechanisms associated with the southern final warming are discussed. The potential for future work involving coupled chemistry/transport studies of southern winter and the southern final warming will also be discussed.

NOCTILUCENT CLOUDS INVESTIGATION FROM THE "MIR" SPACECRAFT

A.I. Lazarev (State Optical Institute, 199034, Sankt-Petersburg, Russia)
A.Yu. Kaleri (Korolev Rocket and Spacecraft Corporation, Kaliningrad, Moscow region, Russia)

Results of the regular visual observations of the noctilucent clouds (NLC) from the "Mir" manned orbital station are presented. We claim that there is no difference between the NLC and the polar mesospheric clouds (PMC). It is an indication of the relatively high water vapor concentration (over 10^{-5}) in mesopause over the whole Earth. The only source of vapor can be the mini-comets. We observed ten cases of NLC occurrence with very small horizontal dimensions (less than 100 km) and lifetime of only 0.5-3 minutes. It was the very first observations of the small-sized NLC and their detailed structure.The problems of genesis, climatology of NLC as well as relation of their occurrence with other cosmophysical phenomena are considered.

LIDAR MONITORING OF THE MIDDLE ATMOSPHERE TEMPERATURE STRUCTURE ABOVE TABLE MOUNTAIN (34.4°N) AND MAUNA LOA (19.5°N) BETWEEN 1988 AND 1996.

T. Leblanc and I. S. McDermid (Jet Propulsion Laboratory, California Institute of Technology, Table Mountain Facility, PO Box 367, Wrightwood, CA 92397, USA)

Temperature profiles obtained with the JPL lidar systems operating at Table Mountain, California (TMF, 34.4°N, 117.7°W) and at Mauna Loa, Hawaii (MLO, 19.5°N, 155.6°W) will be presented. Regular measurements began at TMF in 1988 and at MLO in 1993. The 353 nm Rayleigh signal was used at both locations to retrieve the temperature between approximately 25-km and 90-km, and at MLO the N_2 vibrational Raman signal at 382-nm was used to extend the temperature measurement below 15-km. The observed stratospheric and mesospheric temperature fluctuations at various temporal and vertical scales will be reviewed. A semi-annual temperature oscillation is clearly observed above MLO between 25 and 90 km altitude and an annual cycle is observed below 25 km. Both annual and semi-annual cycles are observed above TMF. Gravity waves fluctuations in the stratosphere and mesospheric temperature inversions are also clearly observed at both locations, as well as a tidal signature at MLO above 60 km of altitude. Inter-comparisons with the CIRA 86 model will be presented. Important departures from the CIRA model are mostly observed above 55 km.

LIDAR OBSERVATIONS OF MESOSPHERIC TEMPERATURE INVERSIONS AT TABLE MOUNTAIN (34.4°N) AND MAUNA LOA (19.5°N).

T. Leblanc and I. S. McDermid (Jet Propulsion Laboratory, California Institute of Technology, Table Mountain Facility, PO Box 367, Wrightwood, CA 92397, USA)

Strong inversions in the vertical temperature gradient (from negative to positive) are frequently observed in the mesosphere. These so-called "temperature inversion layers" have mainly been observed near 70-km altitude for winter mid-latitudes using Rayleigh lidar and satellite measurements. Temperature inversions near 80-km altitude have also been observed by satellite measurements at lower latitudes a at the equinoxes. Several mechanisms have been proposed to explain their formation, involving such various processes as the breaking of gravity waves, tides, and chemical reactions. Recent results, using temperature measurements made by the Jet Propulsion Laboratory (JPL) lidar systems, located at the Table Mountain Facility (TMF, 34.4°N, 117.7°W) and Mauna Loa Observatory (MLO, 19.5°N, 155.6°W) are presented. The 1988-96 climatology of the inversions above TMF shows a strong annual cycle in their amplitude (temperature at top - temperature at bottom), with a maximum in winter. The mean altitude of the inversions is about 70-km. The 1993-96 climatology above MLO shows a strong semi-annual cycle, with a maximum amplitude in April and October. These inversions are located about 75 to 80-km altitude, i.e., higher than the winter inversions observed at TMF. The results, for both locations, are in good agreement with the climatologies previously developed using lidars at other locations and satellite measurements.

EVALUATION AND OPTIMIZATION OF LIDAR TEMPERATURE ANALYSIS ALOGORITHMS USING SIMULATED DATA

T. Leblanc and I. S. McDermid (Jet Propulsion Laboratory, California Institute of Technology, Table Mountain Facility, PO Box 367, Wrightwood, CA 92397, USA)
A. Hauchecorne and P. Keckhut, (Service d'Aeronomie du CNRS, BP3, 91371 Verrieres-le-Buisson cedex, France)

A computer program has been to evaluate the accuracy of the Rayleigh and Raman lidar temperature analysis. The evaluation and the optimization of the algorithms can be performed for various instruments, given their characteristics. The JPL and CNRS temperature algorithms have been tested. Significant improvements to these algorithms were made using the results from the simulations. The program creates simulated data, at different processing levels, as if they were obtained by real measurements, but starting with a known original profile. The simulated data are then processed and the results are compared to the original profile. Various sources of error or inaccuracy met in the analysis processing are reviewed, such as smoothing, density normalization, altitude determination, and background correction. Comparisons of results obtained with older and more recent algorithms are finally presented showing that such simulations could be used in the future for other temperature lidar instruments, notably within the Network for Detection of Stratospheric Change (NDSC).

IONOSPHERIC BURSTS INDUCED BY SOLAR X-RAY FLARES

Musatenko S.I., Kurochka E.V., Astronomical Observatory of the Kyiv University, Kyiv, 254053, Ukraine.
Kutuzov S.M., Astronomical Centre of Academy Sciences of Russia, Pushchino, Moscow Region, Russia.

Observations of the ionospheric radionoise were carried out with high sensitivity near 1.E-26 W/m2Hz and power resolution less than 1 angular degree on the wavelength 3 m. The following results were obtained: 1. The majority of the ionospheric radionoises events are the short (dt<1s) impulsive bursts. 2.Probability of the bursts increased up to 10-100 times after and during the solar X-ray flares. 3. The increase of the X-ray flux caused the increase of the burst density in higher degree than it's amplitude. 4. Sizes of the generation source are limited to several kilometers cubed on the height 60 km. 5. Several significant bursts existed (near 1.E-22 W/m2 Hz). Their sources' sizes were more than 10 kilometer cubed, but these events were rare (one per hour). These bursts are explained by existence of the discharges in the upper atmosphere.

MESOSPHERIC TEMPERATURES MEASURED BY THE CRISTA EXPERIMENT

J. Oberheide, P. Preusse, M. Riese, D. Offermann, K.U. Grossmann; Department of Physics, Wuppertal University (BUGW), Gauss-Str. 20, D-42119 Wuppertal, Germany

Thermal emissions of several trace gases have been measured by the CRyogenic Infrared Spectrometers and Telescopes for the Atmosphere (CRISTA) instrument. CO_2 emissions were converted to height profiles of atmospheric temperature. Respective results with emphasis on the mesosphere will be discussed and maps of global temperatures will also be presented.

The tropical stratopause in UKMO stratospheric analyses: evidence for a 2-day wave and inertial circulations

Y. J. Orsolini ,Météo-France, CNRM, Toulouse, France
V. Limpasuvan, C. B. Leovy, U. of Washington, Seattle, USA

The 2-day wave is a westward-propagating planetary wave which appears recurrently in the summer subtropical upper stratosphere. Evidence is shown of a 2-day wave in the UK Meteorological Office stratospheric analyses during January. Spectral analysis of dynamical quantities and off-line transport of water vapor by the assimilated wind fields are carried out. By contrast, the winter subtropics are characterized by mixing on less-than-planetary scales. Water vapor is mixed turbulently into gyres, and filaments are drawn out the southern hemisphere.
A comparison is drawn with water vapor along-track observations from the MLS instrument aboard UARS. A possible mechanism connecting the initiation of the austral 2-day wave events to strong planetary wave activity in the winter hemisphere is proposed.

Laminae in ozone, water vapor, nitrous oxide, methane and halocarbons over mid-latitudes

Y. J. Orsolini, F. Karcher (Météo-France/CNRM), A. Engel (Inst. of Meteorology and Geophysics, U. of Frankfurt), J. Ovarlez, C. Claud (LMD/CNRS), G. Manney (NASA JPL), L. Coy (NASA GSFC)

A series of balloon flights were conducted in March 1993 from Aire-sur-Adour in southern France, aimed at making in-situ measurements of a variety of trace gases within the polar vortex during a dynamically active period. Meteorological analyses indicate that the balloons were launched when the vortex edge was passing aloft. These mid-latitude balloon flights revealed coincident laminations in ozone, water vapor, and long-lived tropospheric source gases, such as nitrous oxide, methane, halocarbons. Using several sets of meteorological analyses and trace constituent data derived from the UARS observations, isentropic fine-scale distributions of such tracers are produced. Interleaved, slanting sheets of mid-latitude and polar air, hence of different trace gases content, are shown to give rise to the profile lamination in the vortex edge region.

SENSITIVITY OF THE MIDDLE ATMOSPHERE TO CL-BR LOADING STUDIED WITH A THREE-DIMENSIONAL CHEMICAL-TRANSPORT MODEL

G. Pitari, **L. Ricciardulli** and G. Visconti (Dipartimento di Fisica, Università de L'Aquila, 67010 Coppito, L'Aquila, Italy)

The chemical composition of the middle atmosphere and its sensitivity to Cl and Br species time variations are studied with a chemical-transport model (CTM) including a fully interactive microphysical code for aerosol formation and evolution. The model is used to study the long term variability of the atmospheric chemical composition in two scenarios: in the baseline case the surface fluxes of longlived species follow the indication of the Montreal protocol and the successive Copenhagen amendment. The perturbed case is that of the hypothetical CFC emmission expected without the Montreal protocol ('free-market'), with a tropospheric chlorine loading predicted for the year 2000 of about 9 ppbv, instead of less than 4 ppbv in the 'Montreal case'. The time-dependent model simulations are performed from year 1970 up to 2000, including the major SO2 volcanic perturbations during this period and studying the effects of the eruptions on aerosols and ozone. The baseline simulation shows the formation of the ozone hole during mid 1980's and a significant global ozone decrease since late 1990's. The limitation of CFC emissions enforced by the Montreal protocol produces a slight ozone recovery after 1996. In the 'free-market' case the prediction is that of a more dramatic ozone hole with constant deepening from 1970 to 2000 and a global ozone depletion of 9 % in the year 2000 with respect to 1970, compared with 3 % in the baseline case.

STUDY OF LEE WAVES BY MST RADAR OVER NORTHERN SCANDINAVIA

A. Réchou, V. Barabash, S. Kirkwood, T. Savitskaya and K. Stebel
(Institutet för Rymdfysik, Box 812, S-981 28 Kiruna,Sweden)

A campaign to study mountain lee waves using MST radars, backscatter and ozone lidars in Kiruna and Andoya and the ALIS camera system in Kiruna will take place during winter 1996/1997 (from December 27 to February 2). The instruments are located above the polar circle and on both sides of the Scandinavian mountains. This experiment will analyse the influence of the lee waves in the stratosphere on the formation of Polar Stratospheric Clouds (PSCs). This poster will concentrate on the ESRAD MST radar observations from Kiruna. The MST radar is located at ESRANGE [68. °N, 21. °E] to the east of the Scandinavian mountains and operates at 52 MHz. It has 72kW peak power (12 modules of 6 kW each) and a square antenna array consisting of 140-5 element yagis. The yagis can be grouped in different ways and the signal channelled to 6 different receivers. Winds, velocity perturbations associated with waves, and characteristics of turbulence will be studied from 1 km up to 10-15km altitude, with a resolution of 300 m. The observations will be used to characterise the mountain lee waves and their dependance on topography and synoptic conditions (background winds and temperatures).

SENSITIVITY STUDIES OF THE DYNAMICAL COUPLING OF CHEMISTRY AND RADIATION IN A 3-D CIRCULATION MODEL OF THE MIDDLE ATMOSPHERE

Th. Reddmann, R. Ruhnke and W. Kouker (Institut für Meteorologie und Klimaforschung, Postf. 3640, 76021 Karlsruhe, Germany)

A detailed chemistry scheme for the middle atmosphere up to 70 km has been added to the 3-D circulation model KASIMA. KASIMA solves the set of the meteorological primitive equations in spectral form and includes a physical parameterization for the heating and cooling rates and a Lindzen type parameterization for gravity wave breaking. Using datasets of ECMWF analyses at 10 km for the lower boundary of the year 1992/93 the coupling of chemistry and dynamics by ozone is studied with two model versions: First the net heating rates are determined using a climatological ozone field; in the second version the ozone field is derived in the model itself by the chemistry and transport modules. The two model outputs are compared with respect to temperature and wind fields, but also the influence on the transport of chemical tracers is studied. Further the effects of initialization of the chemical species and the influence of different heating rate parameterizations will be discussed.

VARIABILITY OF THE CONCENTRATION OF NIGHT-TIME STRATOSPHERIC NO_3 IN VERTICAL PROFILES OBTAINED FROM BALLOON MEASUREMENTS. COMPARISON WITH MODELS

J.-B. Renard, M. Pirre, C. Robert (LPCE-CNRS, 3A avenue de la recherche scientifique, 45071 Orléans cedex 2, France)
D. Huguenin (Observatoire de Genève, Sauverny, Suisse)

Observations of night-time stratospheric species were performed by the AMON instrument on May 24, 1992, October 16, 1993, March 24, 1994 from Aire sur l'Adour, and on February 10, 1995, from Kiruna. AMON is composed of a UV-visible spectrometer and used the stellar occultation method. After inversion, the vertical profile of NO_3, as well as the vertical distribution of the extinction coefficient of aerosols, are obtained in the 15-39 km range.
These profiles are compared with results of a box model constrained by ozone and temperature measured by AMON. Large discrepancies between observations and models appear for the 1992, 1993 and 1994 profiles at mid latitudes, while the aerosol content, mainly coming from the Pinatubo ejection, was significant. Some peaks of concentrations, of a few km width, can be due to temperature variations in the middle stratosphere, but others peaks may involve some (unknown) heterogeneous reaction with aerosols. A better agreement is obtained for the 1995 flight at high latitude on the polar vortex.

STRATOSPHERIC TRACE GAS DISTRIBUTIONS MEASURED BY THE CRYOGENIC INFRARED SPECTROMETERS AND TELESCOPES FOR THE ATMOSPHERE (CRISTA) EXPERIMENT

M. Riese, K.U. Grossmann, D. Offermann; Department of Physics, Wuppertal University (BUGW), Gauss-Str. 20, D-42119 Wuppertal, Germany

The CRISTA instrument aboard the Shuttle Pallet Satellite (SPAS) was flown on STS 66 in early November 1994. About 50000 height profiles of atmospheric trace gas emissions (15 to 180 km) were measured during a free flying period of 7 days. An experiment description will be given and the global distribution of several measured trace gases (CFC11, HNO_3, $ClONO_2$, ...) will be discussed with emphasis on small and medium scale dynamical structures.

A COMPARISON OF THE DISTRIBUTION OF CHEMICAL TRACE SPECIES BETWEEN AN OFF-LINE AND A COUPLED ON-LINE 3-D CIRCULATION MODEL

R. Ruhnke, W. Kouker, Th. Reddmann and H. Fischer (Institut für Meteorologie und Klimaforschung, Forschungszentrum Karlsruhe, Germany)

A detailed chemistry scheme has been included in the 3-D circulation model of the stratosphere KASIMA. The transport of the chemical species within KASIMA can either be studied off-line driving the model with ECMWF analyses or on-line by solving the set of primitive equations in spectral form.
The results of two simulations for the 1992-1993 northern hemispheric winter are presented. One integration has been performed using the off-line model with a T42 horizontal resolution and 21 levels up to 10 hPa. The other integration has been carried out with a coupled T42 version of the on-line model with 63 levels between 10 and 120 km. In the coupled version the chemical species are not only transported, but the derived ozone field is used in radiative transfer to calculate the net heating rates. The results show the effect of the different wind and temperature fields used in the integrations on the distribution of trace species, with emphasis on the partitioning of the nitrogen species.

MAS OBSERVATIONS AT 61.15 GHZ, ZPM MODEL PREDICTIONS AND A LOWER TEMPERATURE LIMIT AT THE MESOPAUSE

M.L.Richards (Max-Planck-Institute fuer Aeronomie (MPAe), Max-Planck-Str. 2, 37191 Katlenburg-Lindau, Germany)
M.G.Cotton (National Telecommunications and Information Administration, Institute for Telecommunication Sciences, 325 Broadway, Boulder, CO 80303-3328, USA)
G.K.Hartmann and W.Degenhardt (MPAe)
G.A.Hufford (NTIA/ITS)

The Millimeter-wave Atmospheric Sounder (MAS) on board NASA's shuttle mission ATLAS 3 (November 1994) measured emissions of molecular oxygen at 61.15 GHz along limb path scans. The data show Zeeman-splitting of the emissions in the geomagnetic field and the low pressures of upper stratosphere and lower mesosphere. The ZPM model indicates a possible method of direct interpretation of these data in terms of a lower limit of the temperature at the mesopause. Results from the ATLAS 3 mission will be discussed.

THE RELATION BETWEEN VERTICAL VELOCITY AND ECHO POWER OBSERVED WITH THE SOUSY VHF RADAR IN THE TROPOSPHERE

R. Rüster[1], G.D. Nastrom[2], and G. Schmidt[1]
[1] Max-Planck-Institut für Aeronomie, 37189 Katlenburg-Lindau, Germany
[2] Department of Earth Sciences, St. Cloud State University, St. Cloud, MN 56301, USA

The perturbations to the static stability (and hence to the radar reflectivity) and to the velocity in a vertically propagating gravity wave are correlated, and the sign of the correlation depends on the propagation direction. In this paper the wave-induced correlation between radar reflectivity and vertical velocity to explain the downward bias in long-term averages of the vertical velocity is tested. Observations at troposphere heights with very high time- and vertical-resolution have been carried out using the SOUSY VHF radar. It is found that the mean vertical velocity in the mid-troposphere (2.4-6.3 km) is downward (upward) when the perturbations to vertical velocity and to backscattered power over this height range are negatively (positively) correlated.

THE LOWEST OSCILLATION'S MODE OF THE ACOUSTIC GRAVITY WAVES AND IT'S INSTABILITY IN NONISOTHERMAL ATMOSPHERE

O.N. Savina (Technical University, Minina st. 24, 603600, Nizhny Novgorod, Russia)

In this work we discuss the model problem about finding the lowest mode of the high frequency acoustic gravity waves. For analytical approximation the real altitude profile of atmospheric temperature we find an exact solution for altitude dependence on vertical speed of the atmosphere and an expression of the cut frequency w in the nonisotermal atmosphere. It shown, that the nonlinear waves absorption effects on the frequency w . In case when the waves propagates vertically the value w increases. On the basis of results of the solution of the model problem about finding the lowest mode of the acoustic gravity waves with w frequency we conclude that in nonisothermal atmosphere the cut frequency w can be smaller than Brunt-Vaisala frequency w . In this case the acoustic gravity wave instability can be possible. The estimation of this instability increment was obtained.

RESPONSE OF THE STRATOSPHERE TO CONSTANT EXTERNAL FORCING.

A. A. Scaife
(The Meteorological Office, London Rd, Bracknell, Berkshire, U.K.)

A primitive equation model of the stratosphere and mesosphere is used to investigate middle atmosphere flow under perpetual January conditions, with constant forcing from the troposphere. For low wave forcing, the model has steady solutions which are close to the solution with no wave forcing and radiative equilibrium. Above some critical wave amplitude the model has vacillating solutions, as found in quasi-geostrophic β-channel models truncated to zonal wave 1 (Holton and Mass 1976). These vacillations are associated with strong sudden warmings, showing that for the primitive equations, spontaneous warmings can be generated without pulses in tropospheric wave amplitudes. The dependence of the critical wave amplitude on wavenumber is also investigated. One feature of the current integrations not reported in the simpler models is a smaller amplitude oscillation in zonal mean wind with a timescale of a few days. This oscillation appears to be related to wave-wave interactions and the generation of higher wave numbers from zonal wave 1. Similarities between these idealised integrations and the observed stratosphere are also noted.

THE EQUATORIAL QUASI-BIENNIAL AND SEMI-ANNUAL OSCILLATIONS IN SSU ANALYSES.

A. A. Scaife, R.Swinbank
(The Meteorological Office, London Rd, Bracknell, Berkshire, U. K.)

SSU geopotential height analyses, derived from satellite soundings of the stratosphere, show clear QBO and SAO signals. Three analyses are compared: geostrophic analysis of SSU height data interpolated to the equator, curvature relation applied to the SSU height data, and UKMO assimilated data. Both analyses of the SSU data underestimate the strength and duration of the westerly QBO phase but the curvature relation is the more accurate. Because the centred finite difference form of the curvature relation is almost identical to that for interpolated geostrophy but for a factor of 2 in resolution, we infer that resolution is the most important factor in analysing the strength and duration of the QBO westerlies. Differences between the assimilated data and simple analysis of SSU heights include the greater altitude of QBO wind maxima in the SSU analyses, leading to a weak vertical wind shear in these data. However, the westerly phase of the SAO is stronger and more accurate in the SSU analyses than assimilated data, presumably because the numerical model used in the assimilation process does not accurately simulate the westerly SAO phase; a common problem with GCMs.

THE OCCURRENCE OF OZONE MINI-HOLE EVENTS DURING WINTERTIME STRATOSPHERIC WARMINGS

M. Schurwanz, D. Peters (Institut für Atmosphären Physik an der Universität Rostock, Schloss-Str. 4-6, D-18225 Kühlungsborn, Germany),
P. James (Meteorologisches Institut, Universität München,
Theresienstr. 37, D-80333 München, Germany)

An ozone mini-hole is a synoptic-scale area of strongly depleted column total ozone amounts, which undergoes a cycle of growth and decay in direct association with tropospheric weather events. However, it is also known that stratospheric dynamics can have a significant impact on the depth and extent of mini-hole events. In particular, the position and intensity of the stratospheric polar vortex plays an important role. To investigate this, the dynamics associated with ozone mini-holes during periods of wintertime stratospheric warmings, together with their mean frequency and geographical distribution at these times, is analysed and compared with a general climatology of ozone mini-holes over the northern hemisphere based on Nimbus-7 TOMS data. The stratospheric warmings are classified into two types: those with a dominant wavenumber-1 structure, and those with a strong wavenumber-2 component. To illustrate mini-hole development in each class of warming, typical case-studies are chosen and results of Contour Advection calculations are shown to characterize the motion fields. Wavenumber-1 warmings exhibit a significant increase in mini-hole occurrence over the European region, with a corresponding reduction in occurrence over the N. American region, while wavenumber-2 warmings exhibit the opposite changes.

GROUND-BASED MICROWAVE MEASUREMENTS OF H_2O AND O_3 IN THE ARCTIC MIDDLE ATMOSPHERE

C. Seele, P. Hartogh, Ch. Jarchow and Song Li (Max-Planck-Institut für Aeronomie, Postfach 20, D-37189 Katlenburg-Li ndau, Germany)

Ground-based microwave measurements of middle atmospheric trace gases provide a cheap and effective way to collect data for local variabilities and long term atmospheric trends. At our institute we have developed high-resolution heterodyne spectrometers which we use to continuously monitor the emission lines of H_2O at 22 GHz and O_3 at 142 GHz. H_2O provides the major source for HO_x radicals which play an increasing role in the O_3 depletion reactions with higher altitudes. Furthermore it has an essential role in understanding the formation of NLCs. The measurements were taken at high northern latitudes (Andenes, 69.3°N) and represent the first groundbased water vapour data measured above the arctic circle. Furthermore it is the only simultaneous measurement of H_2O and O_3 at arctic latitudes. Our data covers the period from Nov 95 to May 96 (O_3) respectively Oct 96 (H_2O). Beside a description of our radiometer with the CTS backend we present profiles of both species that show annual and inter-annual variability.

Stratospheric nitric acid and total reactive nitrogen measurements by different balloon-borne methods

St. Spreng, K. Gollinger, and F. Arnold (Max-Planck-Institut für Kernphysik (MPIK), Postfach 10 39 80, D-69029 Heidelberg)
M. Koike, Y. Kondo, and T. Sugita (Solar-Terrestrial Environment Laboratory, University of Nagoya (UN), Toyokawa, Aichi, 442, Japan)
C. Camy-Peyret (Laboratoire de Physique Moléculaire et Applications à Université P. et M. Curie (LPMA), 4, Place Jussieu, F-75252 Paris)
R. Blatherwick (Department of Physics, University of Denver, University Park, Denver, Colorado 80208, USA)

Nitric acid (HNO_3) and total reactive nitrogen (NO_y) were measured at mid-latitudes within SESAME in October 1994 using balloon-borne *in-situ* (ion molecule reaction mass spectrometry = IMR-MS of MPIK; NO_y-chemiluminiscence detector = NO_y-CD of UN) and remote-sensing (infrared Fourier-transformation spectrometer = FTIR of LPMA) instruments. For the first time *in-situ* intercomparison measurements of HNO_3 and NO_y were performed by IMR-MS and NO_y-CD at the same location within a time span of less than one day. The obtained VMR profiles will be presented and compared with the FTIR data which were obtained two weeks later at the same location. The implications for nitrogen partitioning will be discussed.

VERTICAL PROFILES OF SULFUR HEXAFLUORIDE IN THE STRATOSPHERE: FROM FLASK MEASUREMENTS TO IN-SITU GASCHROMATOGRAPHY

M. Strunk, A. Engel, U. Schmidt (Institut für Meteorologie und Geophysik, Georg Voigt-Str. 14, 60325 Frankfurt, Deutschland)

The concept of the „age of stratospheric air" has become an extremely important tool to gain further insights in dynamic processes like transport and mixing in the stratosphere. Sulfur hexafluoride (SF_6) is regarded as a powerful tracer to determine the age of stratospheric air samples with a high accuracy. However, only few stratospheric SF_6-data have been available so far.
Recent vertical profiles of SF_6-mixing ratios in the arctic stratosphere are presented, obtained from balloon-borne whole air sampling and subsequent gas-chromatographic analysis with electron capture detection. Furthermore, the concept of a new balloon-borne in-situ SF_6-chromatograph will be presented, which is being developed within the EU founded project „LITES". This chromatograph will be capable to determine stratospheric SF_6-mixing ratios with a time resolution of 1 minute.

MIDDLE ATMOSPHERE VARIABILITY IN THE UKMO UNIFIED MODEL

R. Swinbank (UKMO, London Road, Bracknell, RG12 2SZ, UK)
W. A. Lahoz (CGAM, University of Reading RG6 6BB, UK)

The middle atmosphere variability of several multi-year runs of the troposphere-stratosphere configuration of the UKMO Unified Model (UM) is studied and compared with UKMO analyses and results from other middle atmosphere General Circulation Models (GCMs). The main features, capabilities and problem areas of the UM are discussed. In particular, it is shown that the UM produces a very good simulation of the stratospheric circulation and its seasonal evolution. Time series of 10 hPa polar temperatures show realistic behaviour in both hemispheres. The southern hemisphere winter polar night jet has a realistic magnitude and exhibits little interannual variability, while the northern hemisphere jet exhibits considerable interannual variability (as observed). In common with other middle atmosphere GCMs, the UM has a cold bias in the stratosphere and does not simulate the Quasi-Biennial Oscillation. Future work with the UM on the impact of the stratosphere on tropospheric climate will be discussed briefly.

ON DISRIBUTION OF AEOSOL PARTICLES IN TEMPERATURE STRATIFIED MIDDLE ATMOSPHERE

G.M. Teptin and L.V. Morozova, P.N. Douriaguine (Physics Department, Kazan State University, 18 Kremlin St., Kazan, 420008, Russia)

At investigation of distribution of aerosols in the middle atmosphere the developed by authors stationary model of aerosol particles distribution in northern hemisphere was used. This model bases on the theory of suspended particles sedimentation in a turbulent temperature-stratified media and on monthly-averaged model of the main meteorological parameters of the earth's atmosphere in the points of standard geographical lattice. On the base of calculations from the model the altitude factors, seasonal and geographical ones, which influence on distribution of aerosol particles concentration, were investigated. Following laws was found: In the layers of atmosphere higher than 30 km seasonal variations of month-averaged values of aerosol particles concentration are more than in troposphere and in bottom stratosphere. These variations are more significant in polar areas than in equatorial ones. Concentration of aerosols is maximal in June and minimal in January. The summer's concentrations are in two times more than winter's ones.

LIDAR OBSERVATIONS OF TIDES IN THE MIDDLE ATMOSPHERE AND THE TIME PROJECT

F. Tissot (Department of Physics, The University of Wales, Aberystwyth, Ceredigion, SY23 3BZ, UK)
G. Thuillier, A. Hauchecorne (Service d'Aéronomie du CNRS, BP 3, 91471 Verrieres-le-buisson, France).

Rayleigh lidars can measure atmospheric tidal signatures in temperature, both in and out of the stratospheric tidal-forcing zone. Despite limitations imposed by noise, and the restriction to night-time measurements only, an analysis technique has been developed which can allow determination of tidal amplitudes and phases. Theoretical knowledge is helpful in distinguishing between diurnal and semi-diurnal tides. Tidal amplitudes and phases are presented from a number of lidar observation sessions. However, distinguishing between the presence of different tidal modes remains particularly difficult from single-site measurements. To overcome this problem, the TIME (TIdal Middle-latitude Experiment) project proposes to group together simultaneous atmospheric soundings in the northern-hemisphere middle-latitudes from several instruments including lidars, radars and OH photometers, etc. Besides direct tidal measurements, this project should also be able to contribute to global circulation models which include the propagation and forcing of tides.

FIRST RESULTS FOR OZONE VARIATIONS DUE TO SOLAR PROTON EVENTS DURING 21-ST AND 22-ND SOLAR CYCLES

Y.K.Tassev, T.K.Yanev, P.I.Y. Velinov and L.N.Mateev (Central Solar-Terrestrial Influences Laboratory, Bulgarian Academy of Sciences, Acad.G.Bonchev Str., Block 3, Sofia 1113, Bulgaria)

It is assumed that by penetration of solar cosmic rays (SCR) into the middle atmosphere the ozone is destructed. However we suppose that at certain altitudes ozone can be created as a result of chain ion reactions taking part in the stratosphere. In this investigation satellite data for ozone density in the atmosphere during SCR in 21-st and 22-nd solar cycles were used. The values of ozone concentration (partial pressure) were taken from profiles of the following heights: 25.5 km, 24.5 km, 23.5 km, 19.5 km, 18.5 km and 11.5 km. The orbits of the satellites passed latitudes from 30° to 90° N and longitudes from 20° to 40° E. Data for the high energy protons were taken from Solar Geophysical Data - Bolder, Colorado. Cosmic ray measurements obtained from the neutral monitor in Kiel, Germany were utilized also. The influence of solar protons from seven energetic intrervals from 4.2 MeV till 850 MeV were studied. As a result of statistical analysis direct cause-effect relationships between ozone creation and SCR at heights 18-19 km have been obtained.

INVESTIGATION OF ATMOSPHERIC GASEOUS AND AEROSOL CONTENTS ABOARD THE SPACE STATION MIR

Yu. M. Timofeyev, V. V. Ivanov, A. V. Poberovsky, A. V. Polyakov (Research Institute of Physics at St.Petersburg State University, Ulyanovskaya 1, St.Petersburg-Petrodvorets, 198904 Russia)
B. V. Dementyev, S. G. Kukin (Lebedev Physical Institute of Russian Academy of Science, 53 Leninsky prospect, Moscow, 117924, Russia)

The principal characteristics of two optical devices (OZONE-MIR and ISTOK-1) operating onboard PRIRODA module are described. The OZONE-MIR spectrometer measures direct solar radiation at slant paths in the 0.26-1.02 um spectral range (~160 channels) during the occultation events. The ISTOK-1 spectroradiometer registers both the solar slant path radiation spectra and limb atmospheric radiation in the 4-16 um spectral range (about 60 channels). Information on the methods of interpreting the space measurement data from the above devices (radiation models, retrieval methods, information content of the measurements) is reported. Potential accuracy of retrieving the atmospheric gaseous (O3, NO2, H2O, CH4, HNO3, N2O, etc.) and aerosol contents is discussed. The results of the space measurements fulfilled over various terrestrial regions in 1996-1997 are analyzed.

METEOROLOGICAL INFLUENCES ON THE IONOSPHERE DURING THE WINTER 1989 - 1990

P.I.Y. Velinov, Y.K.Tassev and P.T.Tonev (Central Solar-Terrestrial Influences Laboratory, Bulgarian Academy of Sciences, Acad. G. Bonchev Str., Block 3, Sofia 1113, Bulgaria)

C.W. Spassov (Geophysical Institute, Acad. G.Bonchev Str., Block 3, Sofia 1113, Bulgaria)

L. Milenkova (National Institute for Meteorology and Hydrology, 66 Trakia Bld., Sofia, Bulgaria)

Some meteorological disturbances on the ionospheric *D*, *E* and *F* regions during the period 1 November 1989 - 14 March 1990 are investigated. As source data used are: *i*) meteorological measurements in Sofia; *ii*) rocket data (profiles of the temperatures, pressure and winds) from Akhtopol station; *iii*) A1-method measurements of critical frequences f_0E, f_0F1 and f_0F2, minimal reflectance frequency $f$min, and boundary frequency f_0Es of the sporadic *E*-layer; *iv*) A3-method absorption measurements in the lower ionosphere by long and middle radiowaves. Complete statistical analysis (autocorrelation-, crosscorrelation-, Fourier-analysis etc.) is made of the considered data and the proper physical interpretation of the tropospheric-ionospheric disturbances is given.

EFFECTS OF SOLAR PROTON EVENTS ON ELECTRICAL CONDUCTIVITIES IN THE IONOSPHERE AND MIDDLE ATMOSPHERE

P.I.Y. Velinov and L.N.Mateev (Central Solar-Terrestrial Influences Laboratory, Bulgarian Academy of Sciences, Acad. G. Bonchev Str., Block 3, Sofia 1113, Bulgaria)
U. Zellhuber (Institute for Astronomy and Astrophysics, University of Tuebingen, Auf der Morgenstelle 10, 72076 Tuebingen, Germany)

A new model is created for the electric conductivities in the region 10 - 1000 km of the middle and upper atmosphere. The main goal in this work is to determine the sensitivity of the components of electric conductivity tensor in the ionosphere towards solar proton events (SPE) which are the most important manifestation of the solar activity. For this purpose we shall consider some of the greatest SPE of the 22-nd solar cycle (19 October 1989) and 19-th solar cycle (23 February 1956). We shall use the improved model for the computation of the electron production rate profiles and electron density profiles. We will use the expressions for the field - aligned, Pedersen and Hall conductivities, taking into account also the positive and negative ion densities in the middle atmosphere. This model is realized on Turbo Pascal algorithmic language. For the evaluation of the SPE effects are used ground and satellite measurements for the spectra of the solar cosmic rays. The components of the electric conductivity tensor are calculated for geomagnetic cut-off rigidity E =10 and 40 MeV. The main SPE influence on conductivities is localized at altitudes 20-100 km, which can increase until 2 orders (for E =40 MeV) and 3 orders (for E =10 MeV) in comparison with the quiet conditions.

SHEAR INSTABILITIES IN THE LOWER STRATOSPHERE AND ASSOCIATED VHF RADAR ECHOES.

R.M. Worthington and L. Thomas (Department of Physics, University of Wales, Aberystwyth, Dyfed, SY23 3BZ, U.K.)

VHF radar is used to measure the wind velocity and radar echo power related to long-period wind perturbations, including gravity waves, which are observed commonly in the lower stratosphere and tropopause region, and sometimes in the troposphere. These wind structures have been identified as either inertia-gravity waves or mountain waves. At heights of maximum wind shear, imbalances are found between the echo powers of a symmetric pair of radar beams, which are expected to be equal; the largest effects are found for conditions of simultaneous high windshear and high aspect sensitivity. These power imbalances could arise from tilted anisotropic scattering layers - a result of, for instance, Kelvin-Helmholtz instabilities generated by the strong wind shears. Measurements of this type may indicate the creation of turbulent layers, and mixing, in the lower stratosphere.

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MEASUREMENTS OF OZONE, NO2, BrO, OClO, AND IO OVER NY-ÅLESUND, SPITSBERGEN FROM 1995 TO 1997

F. Wittrock, S. Dzienus, M. Eisinger*, A. Ladstätter-Weißenmaier, A. Richter and J.P. Burrows (Institute of Environmental Physics, University of Bremen, Kufsteiner Straße, D-28359 Bremen, Germany)
(*present address: Alfred Wegener Institute for Polar and Marine Research, Telegraphenberg A 43, D-14473 Potsdam, Germany)

Measurements of total column and/or slant column amounts of BrO, OClO, IO, NO_2, and O_3 over Ny-Ålesund (79° N) made from late winter in 1995 to spring 1997 are the subject of this study. The trace gases were observed by ground based UV/visible absorption spectroscopy of sunlight scattered from the zenith sky and direct moonlight. Slant columns of the absorbers are derived by means of a Differential Optical Absorption Spectroscopy (DOAS) algorithm.
Diurnal, seasonal and year-to-year variation for all absorber will be presented and interpreted. Additional a comparison with model predictions will be shown. Another focal point is the discussion if IO is present in the stratosphere or not.

FIRST OBSERVATION OF QUASI-2-DAY OSCILLATIONS IN IONOSPHERIC PLASMA FREQUENCY AT FIXED HEIGHTS

D. Altadill, J. G. Solé (Observatori de l'Ebre, Roquetes, Spain) and E. M. Apostolov (Geophysical Institute, Sofia, Bulgaria)

Nine time series of hourly values of plasma frequency at fixed heights, from 170 km to 250 km by a step of 10 km, for Roquetes (40.8 N, 0.3 E) during 1995 are obtained from vertical ionosonde DGS-256 by ionogram's inversion and they are investigated by spectral methods with high frequency resolution. It is found that quasi-2-day oscillation persists in the ionospheric plasma frequency variations during whole year 1995. The period of oscillation lies between 40 and 58 hours, in agreement with previous investigations concerning quasi-2-day oscillation in the ionospheric parameters. The amplitude of oscillation ranges from 0.1 MHz to 0.8 MHz. A detailed study of the quasi-2-day oscillation amplitude variation during 1995 shows the existence of several major events. The results of the present investigation could help to better understanding of the possible mechanisms of dynamical coupling between the middle atmosphere and ionospheric quasi-2-day oscillations.

THE THEORETICAL SPATIAL AND TEMPORAL MODELING QUITE CONDITIONS

S.A. Baykal, ODTU/METU Dept of Aeronautical Engineering, 06531 Ankara, Turkey; A.H. Bilge,TUBITAK, MRC, Gebze-Kocaeli Turkey; Y. Tulunay, ODTU/METU Dept. of Aeronautical Engineering, 06531 Ankara, Turkey

The study of day-to day variability of ionospheric critical frequencies is of scientific interest in view of the causative mechanisms and of great importance in assessing prediction capabilities (Aravindan and Iver, 1990). The variability in ionospheric critical frequency is in communication systems, navigational control applications (Bradley, 1988).Therefore, it is required to be able to develop instantaneous ionospheric models for specific epoch on given days in order to be able to assess the corresponding propagation conditions These may be necessary in retrospective investigations to determine for example reason of communication failure, but more especially they are needed to interpret data collected from remote sensing and target location systems (Bradley 1991). This paper investigates a theoretical model for the spatial and temporal variation of the ionospheric critical frequencies .foF2, values under magnetically quite conditions A bilinear model for spatial dependence of the long term variations is explained by using the least square methods in terms of annual mean support R12 index and geographic latitudes of the stations of interest instead of time. In particular, foF2 values obtained at Slough, Uppsala, Rome, Kiev, Kaliningrad, Lannion, Poitiers, Dourbes the ionospheric COST251:IITS stations are employed and 2D model is presented.

HF RADAR OBSERVATIONS OF EQUATORIAL IONOSPHERIC IRREGULARITIES AND DETERMINATION OF THE IONOSPHERIC ELECTRIC FIELD INFLUENCE ON GROUND LEVEL MAGNETIC FIELDS.

E. Blanc and T. Farges (Laboratoire de détection et de géophysique, Commissariat à l'Energie Atomique, BP12, 91680 Bruyeres Le Chatel, France)

During the International Equatorial Electrojet Year, high resolution vertical HF radar experiments were performed in Ivory Coast (9°24'62"N, 5°37'38"W). Kilometric scale irregularities were observed in the E and F regions of the daytime equatorial ionosphere and in an intermediate region, specific of the equatorial latitudes, and located at 150-160 km. Doppler measurements of the vertical ionization drift provide the ionospheric electric fields. Generally, in quiet magnetic conditions, the observation time of the irregularit.es, produced by the East West electrojet electric field, lasts 4 to 8 hours centered on 12.00 LT. During magnetically disturbed conditions, the irregularities sometimes disappeared when the magnetic field, measured at ground, decreases below a determined threshold. These effects are discussed in terms of the contribution of the ionospheric electric field to the ground level magnetic field.

ON THE SPECTRUM OF THERMOSPHERIC GRAVITY WAVES OBSERVED BY THE SUPERDARN HF RADAR NETWORK

W. A. Bristow and R. A. Greenwald (Both at: Johns Hopkins Applied Physics Laboratory, laurel, MD 20723; 301-953-5000; email: Bill_Bristow@jhuapl.edu)

The spectrum of acoustic gravity waves in the thermosphere observed using the SuperDARN HF radar network will be presented and various features discussed. HF radars are sensitive to medium-scale gravity waves in the thermosphere that interact with the F-region ionization. The interaction of waves in the neutral atmosphere with the ionization is discussed to determine the relationship of the observed spectrum to the gravity-wave spectrum. The observations showed that: (1) The observed spectrum shows peaks at frequencies that correspond to quasi-monochromatic wave packets observed in the time series. (2) The spectrum often shows multiple peaks at harmonic frequencies. (3) The spectrum nearly always shows a background level with a power law decrease having a slope of -5/3. It was also found that the overall level of the spectrum was elevated when gravity waves were present, possibly indicating an energy cascade process from the quasi-monochromatic wave to the power law background.

ON THE PLANETARY ELECTRIC GENERATOR EFFECT UNDER MODEL DISTRIBUTION OF ATMOSPHERIC CONDUCTIVITY

P.A. Bespalov, Yu.V. Chugunov and S.S. Davydenko (Institute of Applied Physics, 46 Ulyanov st., 603600 Nizhny Novgorod, Russia)

The generation of atmospheric electric field and the formation of global current circuit owing to differential rotation of the planet and planetary plasma envelope are considered in the case of inhomogeneously conducting atmosphere. Taking into account both altitude and latitude variation of the atmospheric conductivity, basic set of equations describing the electrodynamics of this planetary electric generator is obtained under the global fair-weather condition. It is pointed out that considered source of atmospheric electricity can provide a significant part of the observed global ground-ionosphere voltage. The Earth-like model of the altitude variation of atmospheric conductivity is assumed including exponential increase with different altitude scales in austausch layer and in stratosphere and longitudinally averaged dependence on latitude Under the above conditions, distributions of the atmospheric electric field and current density provided by the planetary generator is obtained. As seen from the results obtained, latitudinal variation of the atmospheric conductivity can lead to redistribution of the electric field and current density in the atmosphere as compared to the case of latitude-independent conductivity.

RESPONSE OF THE IONOSPHERE TO STRONG TROPOSPHERIC EVENTS

J. Boška and P. Knížová (Institute of Atmospheric Physics, Boční II, 141 31 Prague 4, Czech Republic; pkn@ufa.cas.cz)

The main aim of the paper is to detect the effects of strong tropospheric events on the ionosphere based on ionospheric vertical sounding data measured at the Průhonice Observatory. These effects are analysed during a high solar activity period (winter 1990), and for the sake of comparison also at low solar activity (autumn-winter 1996). The results show that it is possible to detect from ionograms the effects of strong tropospheric events, especially of cold fronts. Changes of the electron density profile, computed from the ionograms, will be presented.

COMPARISON OF IONOSPHERIC STORMS OBSERVED SIMULTANEOUSLY IN ISTANBUL AND ROME

Taner Bulat (University of Istanbul, Faculty of Science, Vezneciler, ISTANBUL/TURKIYE)
Bruno Zolesi (Istituto Nazionale Di Geofisica, ROMA/ITALIA)
Sandro M.Radicella (ICEM-International Centre for Earth,Marine and Environmental Sciences, TRIESTE/ITALY)
Harutyun Agopyan (University of Istanbul, Vocational School of High Technology, 34850, Avcylar, ISTANBUL/TURKIYE)

The aim of present study is to justify the importance of ionospheric model studies and to accentuate their reliability and accuracies of measurements done for disturbed days. Thus, severe **storm sudden commencement** (SSC) effects observed in **Istanbul [41° 02' N; 28° 97'E, LT=(UT+2h)** and **L:1,6]** have been compared in **Rome [41° 8'N; 12° 5' E, LT=(UT+1h)** and **L:1,6]** using ground based magnetic recordings and ionospheric soundings for high geomagnetic activity conditions when the **geomagnetic 3-hourly magnetic activity index** gains a value of **Kp ≥7** for 5 days from 29 October 1968 to 2 November 1968. As a result, **60% of correlation coefficient** has been computed for the whole period of time up to **100% deviations of critical frequencies of the F-layer (f_0F)** with positive and negative phases of local data. And possible mechanisms have been discussed extensively considering major variables and topside window.

RESULTS AND MEANS FOR RADIOPHYSICAL INVESTIGATION OF PROCESSES IN THE IONOSPHERE

Chernogor L.F., S.G. Leus, S.N. Pokhil'ko

Kharkiv State University, Kharkiv 310077, Ukraine

In Kharkiv State University in 1985-1995, it is collected a database of transient processes in the ionosphere due to both solar-terrestrial coupling and action of localized sources like earthquakes, rocet launches, power explosions, etc. It was created hardware and software for active and passive sounding operating practically in a real-time mode. To estimate situation over a $10^{-3} - 1$ Hz band, it was conducted measurement with a magnetometer. Space-time scales of transient processes are determined. In the lower ionosphere these processes usually are aperiodic and they reflect an ionosphere-magnetosphere interaction; in the middle ionosphere these processes are quasiperiodic (period $T \geq 10 - 30$min) and have a large duration (more than 1-2 hours). The disturbances propagate with velocities $\sim 0.3 - 0.7$; $\sim 1 - 2$; $\sim 3 - 4$; $\sim 20 - 50$ km/s.

IONOSPHERIC EMISSION: MEAN OF MONITORING SOLAR TERRESTRIAL PROCESSES

Chernogor L.F., K.P. Garmash, S.G. Leus, S.N. Pokhil'ko

Kharkiv State University, Kharkiv 310077, Ukraine

At Kharkiv State University, it was created a hardware and software for monitoring transient processes in the ionosphere on the bases of measuring and analysing of ionospheric radio frequency noice (IRFN) over f=3 kHz - 30 MHz. The facility is made of a stsndart radio-sets and an IBM compatible PC. It is analized the dependence of general ststistics characteristics of IRFN on time. For instance, on f=1-30 MHz in a daytime histogram of the amplitude of radio frequency noice, this shows approximately a Rayleigh distribution. After sunset and during the night, the mean amplitude of IRFN is 10-30 dB more than the daytime one, the magnitude of diurnal variations decreases with an increase in frequency. The magnitude of an IRFN level forestalls during sunset and lags sunrise approximately by 0, 1 and 2 hours for $f \sim$ 1-2, 4-5 and 10-15 MHz correspondingly.

NATURAL AND ARTIFICIAL ULTRAWIDEBAND PROCESSES IN NEAR-TO-EARTH SPACE

Chernogor L.F., O.V.Lazorenko

Kharkiv State University, Kharkiv 310077, Ukraine

Recently there has increased intrest in analyzing physical processes leading to a generation of signals having ultrawide spectra. This is caused by the analysis method creation and the numerical experiment increasing capabilities. The pressure pulse, the irregular geomagnetic field pulsations, the thunderstorm electromagnetic radiation generating and propagating in the atmosphere, the ionosphere and the magnetosphere and other factors can be considered as the examples of the phenomena discussed. A general peculiarity of such signal propagation is their dispersion distorsion. The numerical calculations of electromagnetic and infrasonic signal dispersion distorsions using our specific software are performed.

THE INVESTIGATION OF LARGE SCALE AND GLOBAL PROCESSES IN THE IONOSPHERE USING AN IONOSONDE NET

Chernogor L.F., O.V.Pakhomova

Kharkiv State University, Kharkiv 310077, Ukraine

On the basis on observation which have been peformed in 1977-1995 on an ionosonde net of the FSU the ionospheric reaction have been analized due to the therminator, solar flares, magnetic stormes and 11 strong earth-quakes, 117 rocet launches, 31 underground nuclear explosions, reentry into the Earth's atmosphere of the space vehicles, the radiation of the MF and HF heating facilities et al. The reeaction of ionosphere reduced to appearence of aperiodic and quasiperiodic processes. The minimum release of energy in the ionosphere, near-to-Earth atmosphere and under the ground, which couses large-scale (100-1000 km) disturbances, equals $W \sim 10^8, 10^{11}$ and 10^{15} J. For global disturbances (1000-10000 km) $W \sim 10^9, 10^{12}$ and 10^{16} J.

E-FIELD VARIABILITY INFLUENCES ON THE THERMOSPHERE AND IONOSPHERE

M. Codrescu, T.J. Fuller-Rowell (CIRES-University of Colorado and NOAA-SEC, 325 Broadway, Boulder, CO 80303, U.S.A.)
J. C. Foster (M.I.T. Haystack Observatory, Off Route 40, Westford, MA 01886, USA)

Joule heating is currently one of the largest sources of uncertainty in the thermosphere energy budget. In numerical models the distribution of Joule heating is generally computed using mean or average convection patterns, resulting in an amount of Joule heating that is proportional to the *square* of the *average* E-field. The component of Joule heating due to rapid or small-scale fluctuations in the E-field is generally ignored. E-field fluctuations are known to exist on a variety of temporal and spatial scales, however, and the actual amount of Joule heating in the thermosphere is proportional to the *average* of the *square* of the E-field. In this paper, newly derived E-field variability patterns associated with the Millstone Hill Electric field model are presented, and an assessment of their importance as an upper-atmosphere energy source using the Coupled Thermosphere Ionosphere Model is offered. It is shown that the inclusion of E-field variability in the high-latitude convection model can significantly increase the amount of Joule heating and can change the global structure of the temperature and winds in the thermosphere. Important effects are also predicted by the model in the ionospheric structure.

AURORAL DISTURBANCES OBSERVED BY IMAGING RIOMETER, OPTICAL INSTRUMENTS AND INCOHERENT SCATTER RADAR

P.N. Collis*, J.K. Hargreaves (Engineering Dept., SECAMS, Univ. of Lancaster, Bailrigg, Lancaster LA1 4YR, UK; *on leave from EISCAT HQ, Kiruna, Sweden.)
B.S. Lanchester (Physics Dept., Southampton Univ., Southampton SO17 1BJ, UK)
P.N. Smith (Dept. Physics and Astronomy, Sussex Univ., Falmer, Brighton, UK)
K.U. Kaila (Dept. Phys. Sci., Oulu Univ., Linnanmaa, FIN-90570 Oulu, Finland)

We present a 2-h interval of observations containing a sequence of three auroral intensifications. In the first of these, a stable auroral arc formed large-scale folds but returned to its quiescent state within a few minutes. The other two cases showed similar initial folds, but both developed into full-scale auroral break-ups. The spatial distribution and dynamics of the auroral features were recorded by a scanning photometer and by white-light all-sky TV systems near the Tromsø site of the EISCAT incoherent scatter radar. The radar itself observed the associated changes in D- and E-region electron density, and other ionospheric quantities, as the aurora passed through the radar beam. At Kilpisjärvi, 83 km from the EISCAT transmitter site, the spatial extent and dynamics of regions of radio absorption were monitored by a 49-beam imaging riometer during the same interval. We compare and contrast the signatures of these disturbances as seen optically and with the riometer, and synthesise the two with the aid of the radar data. Particular attention is given to the spatial relationship between regions of luminosity and radio absorption and to the inferred changes in energy of the precipitating particles during the events.

CONVECTION STUDIES WITH THE EISCAT SVALBARD RADAR AND RELATED INSTRUMENTATION

S W H Cowley (Department of Physics and Astronomy, University of Leicester, Leicester LE1 7RH, UK)

One of the principal objectives of the EISCAT Svalbard Radar is to undertake studies of the convection in the high-latitude ionosphere, and related plasma effects, in coordination with other ground-based instruments and with spacecraft. In this presentation we will review present concepts of the origins of the high-latitude flows which should be accessible to the ESR, and what the new coordinated measurements should contribute to their understanding.

SHORT-TERM PREDICTION OF THE SOLAR PROTON EVENTS ON THE IONOSPHERIC DATA

I. Fedulina I. Kozin, B. Zhumabaev (Institute of ionosphere, Kamenskoe plato, 480068 Almaty, Republic of Kazakstan)

Searching of flare heralds takes a special place in the problem of short-term prediction of a radiation situation in outer space, ionospheric parameter variations and conditions of the radiowave propagation. Here the possibility of short-term prediction of solar proton events on data of ionospheric parameter variations was considered. An analysis of absolute variations of critical frequencies of F2 ionospheric layer Δf_0 F2 was conducted by superimposed epoch method. Two data sets of 10 ionospheric stations were examined separately for daily and nightly periods of 15 solar cosmic ray flares. It was shown that at the stations located in daily sector the decreasing of critical frequencies begins 5 hours before and lasts to solar cosmic ray flare. In night sector such changes were not observed. It may be use for short-term prediction of the solar activity.

LONG-PERIOD VARIATIONS OF IONOSPHERIC F2 LAYER DURING THE FORBUSH EFFECTS IN COSMIC RAYS

I. Fedulina I. Kozin (Institute of ionosphere, Kamenskoe plato, 480068 Almaty, Republic of Kazakstan)

The behavior of midday critical frequency values of ionospheric F2 layer (f_oF2) in the periods of Forbush decreases in cosmic ray intensity I(N) for 1978 was analyzed by superimposed epoch method. Two sets of ionospheric and cosmic ray fluxes data included 9 time series. The duration of each pair was 26 days. The days of I(N) minimum were used as the key days. The beginning of time series was 5 days before the key day. The result sowed that the minimum in the variations of both parameters fell on the key days. The I(N) restoration continued 6 days and no further changes occurred. The f_oF2 restoration continued 5 days. Then the second phase of reduction took place and lasted 4 days, after that the positive phase of disturbance of 8 days happened, and then the ionosphere returned into initial, non-perturbed state during 4 days.

MID-LATITUDE GEOMAGNETIC FIELD LINE RESONANCES RELATED TO UPPER IONOSPHERIC ELECTRON AND ION DENSITY MEASUREMENTS

M. Förster, A. Best, I. Best (GeoForschungsZentrum Potsdam, Telegrafenberg A17, 14473 Potsdam, Germany), and J. Smilauer (Institute of Atmospheric Physics, Bocni II, 14131 Prague, Czech Republic)

Geomagnetic registrations of toroidal field line resonances which are also known as Pc-3 and Pc-4 micropulsations were obtained at the mid-latitude stations L'Aquila (L=1.6), Niemegk (L=2.3), and Nurmijärvi (L=3.3) for the time interval from 19 August to 6 September 1990. This time interval near the maximum of the solar activity cycle is characterized by a large dynamics of both the solar and the geomagnetic activity parameters. For this time interval, ion and electron density measurements were obtained in the upper ionosphere onboard the main satellite Aktivny and its subsatellite Magion-2, respectively. Using a numerical model of the coupled system ionosphere-plasmasphere, the toroidal Eigenmodes of the mid-latitude geomagnetic force lines are calculated and the model plasma densities along the flux tubes are compared with the measured ones. Conclusions are drawn about the diurnal variation and the general dynamics of the system ionosphere-plasmasphere.

EFFECTS OF ADDITIONAL X-MODE HEATING OF THE IONOSPHERIC F-REGION

V.L. Frolov, L.M. Kagan and E.N. Sergeev (Radiophysical Research Institute, B. Pecherskaja st. 25, N.Novgorod, 603600, Russia)
P.A. Bernhardt (Naval Research Laboratory, Washington, D.C. 20375-5000, USA)
P. Stubbe (Max-Plank-Institute fuer Aeronomie, D-37191 Katlenburg-Lindau, Germany)

In order to improve our understanding of the physical processes occurring due to modification of the ionospheric F-region, we have studied the properties of the stimulated electromagnetic emission (SEE) induced by an O-mode HF sounding wave, using the scheme of additional X-mode heating. Experiments were performed at the Sura facility (Russia) during 1995 - 1996. It has been found that the additional X-mode heating is responsible for a suppression of SEE generation through a decrease of the Langmuir turbulence intensity. The typical time scale for a change in the SEE intensity is rather short, not more than $1-2$ s, depending on the scheme of the experiment. An influence of the X-mode heating is observed when the X-mode pump power exceeds a value of ~ 20 MW ERP, and is more clearly defined when the reflection levels for the O- and X-mode waves coincide. Aftereffects of the X-mode modification last for a few tens of seconds. It is stated that the phenomena observed are the result of modification of the ionospheric F-region in the vicinity of the X mode reflection level.

NEW SEE FEATURES

V.L. Frolov and E.N. Sergeev (Radiophysical Research Institute, B. Pecherskaja st. 25, N.Novgorod, 603600, Russia)
P. Stubbe (Max-Plank-Institute fuer Aeronomie, D-37191 Katlenburg-Lindau, Germany)
B. Thidé (Swedish Institute of Space Physics, S-75591 Uppsala, Sweden)

Fifteen years after its discovery, the phenomenon of stimulated electromagnetic emission (SEE) still reveals new properties. A new type of wideband emission, which we have called BUS (broad upshifted structure), is observed in frequency ranges between gyroharmonics at frequencies upshifted by up to $60-170$ kHz from the pump frequency. The BUS either has a spectral maximum at offset frequencies of about $15-35$ kHz or is observed as a "plateau". New experiments have also been performed on the BUM (broad upshifted maximum) feature. It has been found that the BUM contains at least two components, one of wich shows intensification of its generation under the effect of HF accelerated electrons. The other subject of interest is the DM (downshifted maximum). New detailed experiments have shown that there is a dependence of the DM frequency shift (Δf_{DM}) on pump power. An offset of the DM to more negative frequency shifts is observed when additional O-mode heating is used. It has been found that the frequency shifts of the DM and UM (upshifted maximum) possess the same linear dependence on the pump frequency, and that the difference $|\Delta f_{DM}| - |\Delta f_{UM}| \simeq 2$ kHz is kept constant. We report also that in the NC (narrow continuum) frequency range two different SEE components are observed.

ON INTENSIFICATION OF BUM GENERATION BY ADDITIONAL O-MODE HEATING

V.L. Frolov and E.N. Sergeev (Radiophysical Research Institute, B. Pecherskaja st. 25, N.Novgorod, 603600, Russia)
P.A. Bernhardt (Naval Research Laboratory, Washington, D.C. 20375-5000, USA)
B. Thidé (Swedish Institute of Space Physics, S-75591 Uppsala, Sweden)

We report new results concerning intensification of the BUM (broad upshifted maximum in spectrum of the stimulated electromagnetic emission, SEE) when additional heating by an O-mode powerful wave is used. In such scheme the first wave (the diagnostic wave, DW) is used for inducing of the SEE, the second wave (the heating wave, HW) is used for additional modification of the ionospheric F-region. Experiments were carried out at the Sura facility (Russian) during 1993 — 1995. It has been found that enhancement of the BUM intensity is observed when HW power exceeds of $\sim$ 20 MW ERP and under condition when $f_{DW} - nf_{ce} \simeq 20 - 50$ kHz. The BUM enhancement after the HW turn-on/-off has the typical growth time of order of $3 - 5$ c and the typical e-folding decay time of about $60 - 300$ mc, correspondingly. It is suggested that the intensification of the emission is determined by influence of superthermal electrons on generation of one of two BUM components. In this model electrons are accelerated up to superthermal energy in a plasma resonance region due to thermal parametric instability growth. New opportunities to use the SEE for sounding of the artificial ionospheric turbulence are discussed.

Tomographic reconstruction of the auroral arc emission from stereoscopic observations

S. Frey, Harald U. Frey (Max-Planck-Institute for extraterrestrial physics, D-85740 Garching, Germany)

The auroral arc emission strongly depends on the peak energy and flux of precipitating auroral electrons and on atmospheric chemistry. The main tools for scientific measurement of these quantities are sounding rockets and ionospheric radars. But, ground based optical observations are always used as an additional source of information about the actual auroral situation and the separation of temporal and spatial changes in auroral brightness. In addition to altitude determination and location of auroral structures from optical observations a tomographic reconstruction can yield additional information on the three-dimensional process of electron precipitation. An iterative combination of a modified back-projection and an algebraic reconstruction technique is used for a tomographic reconstruction of the auroral arc emission in addition to ionospheric radar measurements. The radar measurements are used as a-priori information for an increase of reconstruction accuracy. A special example of an arc moving from north to south across the radar beam position is demonstrated and physical quantities of electron precipitation can be estimated for regions outside of the radar beam.

Phase velocity of travelling ionosphere disturbances.

V.D.Gusev, D.V.Kirianov, A.G.Vologdin

M.V.Lomonosov Moscow State University

Faculty of physics, Department of Atmosphere

Russia 119 899 Moscow Vorobyevy Gory

Tel:+095 9393252, Fax:+095 9724437, E-mail: kirianov@atmos.phys.msu.su

Principles of wavy ionosphere disturbances phase velocity determination by measurements of ionosphere radio signal doppler shift and wave vector are investigated. A mathematically justified simple method employing filtration technique and geometric optics approach is presented along with experimental results obtained on radio route London-Moscow.

Typical observations of frequency dependence of phase velocity shows that range of phase velocity is (100-500) m/s and its direction is usually meridional. Normal (i.e. negative) dispersion is intrinsic for disturbances with periods more then 5 min. For periods more than 35 min we never observe velocity growth with frequency. On the contrary for periods (1-3) min weak positive dispersion was registered more often then negative.

SIMULTANEOUS COHERENT BACKSCATTER AND DIGISONDE OBSERVATIONS IN THE MIDLATITUDE E REGION

G. Hussey, K. Schlegel (Max-Planck-Institut für Aeronomie, Postfach 20, D-37189 Katlenburg-Lindau, Germany)
C. Haldoupis (Physics Dept., University of Crete, Iraklion, Crete, Greece)

The SESCAT experiment, a coherent backscatter facility located in Crete,Greece has been operated for one summer together with a digital ionosonde illuminating the same scattering volume. The aim of the investigations was to find more clues about the origin of the E region coherent echoes which occur almost exclusively during summer nights. It was found that sporadic E layers in the scattering volume are one necessary condition for the occurrance of coherent backscatter, but we did not observe these echoes during all sporadic E conditions. Apparently other additional conditions have to be met. A statistical analysis yielded significant correlations between the SESCAT echo strength with f_0E and with the width of the sporadic E layers (both correl. coeff. $\approx$ 0.5). Similar correlations were also obtained for SESCAT spectrum width and the same E_s parameters, while there were no clear correlations between SESCAT mean Doppler shifts and sporadic E parameters. Examples of the results are presented and discussed in the frame of the current theoretical ideas on coherent backscatter from E region plasma irregularities.

IONOSPHERIC INDICATIONS OF LONG-TERM CHANGE IN THE THERMOSPHERE OVER ANTARCTICA

M. J. Jarvis and B. Jenkins (British Antarctic Survey, NERC, Madingley Road, Cambridge CB3 0ET, United Kingdom)

An analysis using the continuous 37-year record of monthly median scaled ionospheric parameters from Argentine Islands observatory, sited at Faraday (now Vernadsky) research station (65S, 64W), Antarctica, has been carried out to investigate whether the altitude of the F-region peak electron concentration exhibits any long-term trend. The analysis indicates a possible decrease in altitude of ~0.2 km per year - a similar trend to that found by Bremer in Europe (J. Atmos. Terr. Phys., 1992, p1505). There are also indications that the magnitude of the diurnal variation in the altitude of the F-region peak driven by the thermospheric wind has decreased over the 37-year period. The effect on the F-region of the 10% decrease in the strength of the local geomagnetic field at Argentine Islands over the same period has been considered.

A NEUTRAL WIND DRIVEN INSTABILITY IN THE IONOSPHERIC E REGION

Kagan L.M., Radiophysical Research Institute, Nizhny Novgorod, Russia

In the upper ionosphere neutral winds resulting in relative motion of charged particles in cross-field direction can be a source of instability growth. Besides well known two-stream and gradient drift instabilities a thermal mechanism can take place. Ion frictional heating caused by ion-neutral collisions results in further plasma forcing out from the regions of depleted plasma. The instability realized in the altitude range 90-130 km with a maximum around the altitude of 110 km. This mechanism seems to explain generation of type 2 field-aligned irregularities associated with observations of mean magnitudes of Doppler velocities less than 100 m/s. For a latitudinal neutral wind in the equatorial zone and a horizontal wind in the polar cap a threshold magnitude of a neutral wind velocity is found to be about 30-60 m/s.

THE SMALL-SCALE INSTABILITY OF INHOMOGENEOUS PLASMA IN THE IONOSPHERIC F-REGION

Kagan L.M., Radiophysical Research Institute, Nizhny Novgorod, Russia

Large-scale inhomogeneities imbedded into electric field are find to be not only a direct source of plasma instability as in gradient-drift mechanism but a mediated one also, which results in generation of a local polarization electric field, leading to plasma forcing out in plasma depletions. The necessary feedback is provided by electron temperature fluctuations. The mechanism operates at the altitudes of the F region and is shown to be realized into both the auroral and heater-modified ionospheres. The field-perpendicular scale of induced small-scale irregularities depends only on a scale-length of plasma density gradient and values of plasma parameters, but not on the magnitude of the imposed electric field.

THE EFFECT OF ELECTROSTATIC FIELD ASSOSIATED WITH THE TROPOSPHERIC LINE OF SQUALLS ON THE NIGHT-TIME MID-LATITUDE E-REGION

V.P.Kim and V.V.Hegai (Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, Russian Academy of Sciences, Troitsk, Moscow Region, 142092 Russia)

The distribution of electrostatic field produced in the ionosphere by the tropospheric line of squalls and effects of the field on the night-time mid-latitude E-region are calculated. It is found that the value of electric field strength may be as large as 3 mV/m. The electron density in the E-region above the tropospheric line of squalls falls strongly (up to 3.5 times) relative to the undisturbed level.The horizontal size of the disturbed area is about 200 km.

EFFECTS OF THE DYNAMO ELECTRIC FIELD ON THE WINDS IN THE LOWER THERMOSPHERE

Yu.N.Korenkov, V.V.Klimenko, F.S. Bessarab (WD IZMIRAN, Pobedy av. 41, Kaliningrad, 236017, Russia)

The global numerical self-consistent and time-dependet model of the thermosphere, ionosphere and protonosphere (GSM TIP) was used for the investigations of the effects of the electric fields of the dynamo origin on the behavior of the neutral gas flow in the lower thermosphere at the heights range of about 140 km. Numerical calculations of the global distributions of thermosphere -ionosphere parameters were performed with using of the empirical model of the neutral atmosphere parameter MSIS-86 for the high solar activity and summer conditions. The main feedback mechanism is the effect of the electric fields on the neutral's wind velocity. It was shown that the electric fields at high latitudes assosiated with dynamo mechanism increase the amplitude of the neutral wind all over day. At the middle latitudes the increasing of the amplitude northward component of the neutral wind occurs during evening and night hours. At the low latitudes, the effect of the decreasing of the amplitude southward component of the neutral wind was found. Effects on zonal component of the neutral wind have been considered also. A theoretical explanation for the observed effects are discussed.

TRACE OF A SATELLITE ELECTRODYNAMIC TETHER SYSTEM IN THE NIGHT-TIME MID-LATITUDE E-REGION

V.P.Kim and V.V.Hegai (Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, Russian Academy of Sciences, Troitsk, Moscow Region, 142092 Russia)

Perturbation of charged particles density in the night-time mid-latitude ionospheric E-region due to the electric field generated by a satellite electrodynamic tether system is theoretically studied. It is shown that behind the tether system a strip of disturbed density is formed. For tether length of 100 km the strip size is about 1000 km long and 100 km wide. The charged particles density is changed by 10 - 15 % relatively undisturbed value and its horizontal distribution is irregular in the strip.

DAILY VARIATION IN CONDUCTIVITY AND MAGNETIC VARIATIONS

A. Kohsiek and K. Schlegel (Max-Planck-Institut für Aeronomie, D-37191 Katlenburg-Lindau, Germany)

The daily variation of the geomagnetic field, the Sq-variation, is generated in the ionosphere by tides. These wind driven magnetic variations depend further on the conductivity in the dynamo region. The Sq-variation exhibits a variability from day to day. One possible reason for this are fluctuations in the driving winds, but the daily variabilty of the conductivity may also be responsible. The coupling of the fluctuations in conductivity with the Sq-variations are discussed. For this, conductivities derived form the EISCAT incoherent radar, located in northern Scandinavia, and its magnetometer cross IMAGE are used.

EFFECTS OF THE DYNAMO ELECTRIC FIELD ON THE WINDS IN THE LOWER THERMOSPHERE

Yu.N.Korenkov, V.V.Klimenko, F.S. Bessarab (WD IZMIRAN, Pobedy av. 41, Kaliningrad, 236017, Russia)

The global numerical self-consistent and time-dependent model of the thermosphere, ionosphere and protonosphere (GSM TIP) was used for the investigations of the effects of the electric fields of the dynamo origin on the behaviour of the neutral gas flow in the lower thermosphere at the heights range of about 140 km. Numerical calculations of the global distributions of thermosphere-ionosphere parameters were performed with using of the empirical model of the neutral atmosphere parameter MSIS-86 for the high solar activity and summer conditions. The main feedback mechanism is the effect of the electric fields on the neutral's wind velocity. It was shown that the electric fields at high latitudes associated with dynamo mechanism increase the amplitude of the neutral wind all over day. At the middle latitudes the increasing of the amplitude northward component of the neutral wind occurs during evening and night hours. At the low latitudes, the effect of the decreasing of the amplitude southward component of the neutral wind was found. Effects on zonal component of the neutral wind have been considered also. A theoretical explanation for the observed effects are discussed.

UNIVERSAL VARIATION OF FOF2 AND SOLAR ACTIVITY

V. V. Kuznetsov, V. V. Plotkin, G. V. Nesterova and I. I. Nesterova and **V. V. Kuznetsov** (Institute of Geophysics, University av.,3, Novosibirsk 630090, Russia)

In this paper to study the regular variations of the quiescent F2-layer, we use the universal variation of foF2, that is the dependence of the instantaneous mean-longitudional value of foF2 at the given latitute on the universal time UT. Using the algorithms elaborated by us, we have processed data of Ionospheric Digital Database (Boulder, USA) involving the observation results of ionosphere by the vertical sounding method for the world network (1957- 1990). It is found by us that the type of foF2-universal variation is essentially distinguished for years of minimum and maximum solar activity. In the years of minimum solar activity the universal variation of foF2 is similar the well known universal variation of the atmospheric electric field nealy the Earth's surface with maximum at 19 UT. It is also found that the seasonal change of foF2-universal variation are practically absent in the years of minimum solar activity. In the years of maximum solar activity the type of the foF2-universal variation changes: minimum at 15-16 UT becomes characteristic and small seasonal changes of the universal variation foF2 appear. All of the preceding enables to suggest that under the quite conditions during minimum solar activity the electric field can penetrate from lower atmospheric layers up to heights of ionospheric F2-layer.

PLANETARY WAVE-TYPE OSCILLATIONS IN F-REGION PARAMETERS OVER EUROPE

J. Laštovička and P. Knížová (Institute of Atmospheric Physics, Boční II, 141 31 Prague 4, Czech Republic; jla@ufa.cas.cz)

We will deal with oscillations of foF2 and h'F in the period range of about 4-18 days over Europe. First results (Laštovička and Mlch, Annali di Geofísica, 39, 783-792, 1996), based on data of stations Juliusruh, Lannion, Rome and Průhonice, displayed different long-term (solar cycle and seasonal) behaviour of planetary wave-type activity in foF2 and h'F. These results are extended with data of several other European stations in order to ensure a better geographical coverage of European area. Periods when the effects of planetary wave-type oscillations are negligible or, on the other hand, of real importance for the radio wave propagation predictions, are established.

RELATIONSHIP BETWEEN PARTIAL REFLECTION, IONOSPHERIC ELECTRIC FIELD, AND REMOTE ROCKET LAUNCH

Martynenko S.I., Milovanov Yu.B., Rozumenko V.T., Tymov O.F., Tsymbal A.M. Kharkiv State University, Kharkiv, Ukraine

It has been analyzed partial reflection data collected near Kharkiv, Ukraine, at low geomagnetic (L=2.0) and middle geographic latitudes in the years 1991-1995 during space shuttle launches and landings in the U.S.A. In about 20 per cent of the experiments, there appear perturbations in partial reflection signals in a few minute time after the ignition of the engines, and they last for about 30 min. The 60-66 km data were used to determine electric field and the histogram of its strengths shows that electric field is a frequent feature. It is studied the possible influence of mid-latitudinal electric fields on the development of perturbation in the D region.

SPORADIC LAYERS AS CURRENT GENERATOR UNDER DIFFERENT GEOMAGNETIC CONDITIONS

C.-V. Meister (WIP-Project Space Plasma Physics, Potsdam University)
V.A. Liperovsky (Institute for Physics of the Earth Moscow)

The 3D-model of local current generation by the interaction of dense night-time sporadic E-layers and strong neutral wind pulses in the mid-latitude ionosphere (Ann. Geophys., Suppl. 3 to Vol. 14, C719, 1996) is reconsidered taking into account ion-magnetization and neutral winds in the sporadic layer as well as in the external circuit. The effectivity of the model is numerically analysed for different possible geophysical conditions (altitudes, dimensions of the sporadic layers, neutral particle velocities). It is shown that only under very rare conditions the electron velocities in the sporadic layers reach the critical velocities for the generation of Farley-Buneman turbulence.

The influence of nonstationarity on the signal / noise ratio for multiply ionospheric echoes.

S. F. Mirkotan, V. I. Zakharov, S. Yu. Belov, V. A. Pancheluga (Physical Faculty, Moscow University, Moscow, 119899, Russia).

The quadrature E(t), envelope R(t), phase of the ionospheric echo (IE) are commonly recorded at a distant diagnostics. The paper considers the SW radiowave propagation in the channel Ionosphere--Earth with a "rough" scattering boundaries. The nonstationarity influence because of large-scale border irregularities on the signal/noise ratio β_k^e determination is analyzed. The superscript p = i; e is the ionosphere or earth border; the subscript k = E; R is the register prime parameter. It was assumed that the multiply IE properties are described by the statistic multiplicative model (SM-model) [1]. The recordings of E(t). R(t) fluctuations were subjected to the numerical filter procedure (NFP) to neutralize the nonstationarity ($\tilde{E}$, $\tilde{R}$, where "~" denotes the NFP). It was received that the average value $<\beta_R^e>$ corresponds to energy losses ~ 14 % and $<\tilde{\beta}_R^e> \approx <\tilde{\beta}_E^e> \approx <\beta_E^e>$ — ~ 30 %. So, in reality the energy losses reach 30 % (instead of 5 % of the usual estimation). The estimation of the $<\beta_R^e>$ gives twice less value. The determination of the losses from f_E^e do not need the filtration.

Reference : 1. S.F. Mirkotan, V.I. Zakharov, M.N. Gritsin. Geoinformatica. № 2 (5). Moscow, 1996, p. 20. In Rus.

On ionospheric signal / noise ratio measurement method.

S. F. Mirkotan and S. Yu. Belov (Physical Faculty, Moscow University, Moscow, 119899, Russia).

The ionospheric echo (IE) signal/noise ratio β_k is of interest as the ionospheric plasma concentration measure of disturbance, as well as the communication (or diagnostic) channel characteristic. The paper presents the results of comparison of the measurement methods from the point of view of their admissible relative analytical errors. The new method is suggested. The subscript k=E,R2,R4 indicates the primary parameter recorded (E - quadrature, R - envelope of the IE), and the method used (E-coherent; R2,R4 - noncoherent). Usually in use: 1) the standard R2-method, where $\beta_{R2} = f_{R2}(\alpha_{R2})$ [1]; 2) the coherent E-method, $\beta_E = f_E(\alpha_E)$ [2]. The paper presents the new R4-method, where $\beta_{R4} = f_{R4}(\alpha_{R4})$. Above α_k are the values measured and f_k are the known functions. The comparative analysis of the normalized relative analytical errors $\varepsilon^*_k = (1/\beta_k)\, df_k/d\alpha_k$ of the known methods and the new one was performed. It was shown that the errors ε^*_E and ε^*_{R4} are of the same order ($\varepsilon^*_{R4} = 3/2\ \varepsilon^*_E$) and both are less by one order in comparison with the standard R2-method error ε^*_{R2} [1]. As a result, the sufficient analytical precision of the β_k measurement may be achieved with the simple noncoherent R4-method.

But the coherent E-method reserves the possibility of statistical error optimization with a special processing of the IE.

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THE SENSITIVE OF THE β_E -MEASUREMENT METHOD IN THE SWRANGE.

S. F. Mirkotan, V. I. Zakharov, S. Ju. Belov (Phys. Faculty, Moscow University, Moscow, 119899, Russia).

The measurement, mapping and computation of the "rough" Earth Surface Scattering Power (ESSP) in SW range are of interest for a set of problems(communication, geology, etc.). The ESSP parameter is the signal/noise ratio of the β_E waves reflected from the earth "rough" backing. There is the back of the β_i -data and measuring method is in SW range. In [1] experimental method of β_E -determination is presented.

In the paper this method is tested on the parameter β_E sensitivity. According to the statistical model (SM) [2] the database ("recordings" for the numerical experiment) adequate to the real conditions was created. The properties of the earth polygon basking were defined by the theoretical β_E value. Basing on the method of [1] $\beta_E{}^t$ (numerical experiment) were determined. Then the massifs of the $\beta_E{}^{ex}$ and $\beta_i{}^t$ were compared and analyzed. In this paper the admissible sensitivity and stability of the method [2] were justified. The comparative analysis of the real experimental data and adequate numerical ones were fulfilled. As a result, the plausibility of the ionosphere echo statistical structures used were justified.

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EXPERIMENTAL STUDIES OF THE POLAR IONOSPHERE USING TOMOGRAPHIC TECHNIQUES

Cathryn N. Mitchell, M. J. Williams, L. Kersley, S.E. Pryse, I.K. Walker, C. Willson and S.J. Berry (Department of Physics, The University of Wales, Aberystwyth, SY23 3BZ, UK)

The technique of ionospheric tomography involves the inversion of a large number of intersecting satellite-to-receiver measurements of total electron content (TEC) to yield two-dimensional images of electron density. Results from two experimental campaigns have been used in several case studies of the electron-density distribution in the polar-cap ionosphere. These show features like the tongue of ionisation and structures resulting from soft precipitation in the cusp region, patches convecting in the anti-sunward flow of the central polar cap and the polar hole of the dawn cell in winter. Tomographic images of the day-time trough in the afternoon sector are related to the high-latitude convection pattern determined from satellite data. The recent deployment of a receiver chain at Ny Ålesund, Longyearbyen, Bjørnøya and Tromsø provides new opportunities for imaging the auroral/polar-cap ionosphere in the region between the EISCAT and the EISCAT Svalbard Radars.

THE SOLAR PARTIAL ECLIPSE DURING 12 OCTOBER 1996 AND CORRESPONDENT EFFECTS IN THE IONOSPHERIC RADIONOISES

Musatenko S.I., Suberlyak V.R., Astronomical Observatory of the Kyiv University, Kyiv, 252053 Ukraine.

The effects caused by the partial eclipse of the Sun (maximum phase Fmax=0.63) were registered on the wavelength l=2m. Antenna with two crossed matched dipoles and Dicke radiometer with low own noises' level were utilized. Following effects were detected: 1) Total change of the radio noise amplitudes correlates with 24-hourly change of the electron concentration in the ionospheric E-region; on l=2m the Sun set took place at the zenith distance about 95 degrees. 2) During eclipse the radio noises' level decreased compare to control days. It is correlated with decrease of the electron concentration in the E-region. 3) The anomalous high level of the low-frequency fluctuations with periods near 5-12 min were observed on October 12. The level of the fluctuations were as twice as less at the moment of maximum phase compare with the beginning and the ending of the eclipse.

THE MODULATION FREQUENCY DEPENDANCE OF ARTIFICIAL VLF RADIATION DETECTED IN FAR-FIELD

A. Oikarinen (Dept. of Physical Sciences, Univ. of Oulu, FIN-90570 Oulu, Finland)
J. Manninen, J. Kultima and T. Turunen (Sodankylä Geophysical Observatory, FIN-99600 Sodankylä, Finland)
A. Väänänen (Vaasa Institute of Technology, Vaasa)

Very low-frequency (VLF) radio waves can be generated in the ionosphere by heating. This can be done by powerful HF radio waves which are amplitude-modulated. It has been found that the intensity of the generated artificial VLF signal has some maxima between 2 and 6 kHz. These maxima are due to the VLF waves experiencing constructive interference when signals are reflecting between ground and ionosphere. The occurence of the first maximum is around 2 kHz and spacing between the maxima is about 2 kHz. Measurements of these are usually made at near-field and under the heated ionospheric volume. In our experiments we had the receiving site situated about 100 km from the heater. Ionospheric heating experiments were made by the EISCAT heating facility. It is situated at Ramfjordmoen (69.6° N, 19.2° E, L=6.2) near Tromsø, Norway. The receiving site was located at Porojärvi (69.17° N, 21.47° E, L=6.1, distance from heater 95 km) in Northern Finland. Frequency range from 0.2 to 9.2 kHz was covered. We had two heating experiments which sweeped frequencies. The first one covered frequencies from 500 Hz to 5500 Hz. The sweep was made in one minute. The heating radio wave was 4.04 MHz and it was modulated sinusoi-dally. In the other experiment the frequency range was narrower, 200–2200 Hz. In that experiment we tried both sinusoidal and square wave modulations. In this paper we present some results and compare them to previous experiments.

A STUDY OF COUPLING BETWEEN MIDLATITUDE THUNDERSTORMS AND SPORADIC E-LAYERS FROM RADIO-OBSERVATIONS MADE AT KIEV IN THE PERIOD 1964 TO 1974

A.L.Pasternak and S.I.Musatenko (Kiev State University, Physics Department, pr.Glushkova,6, Kiev-022, Ukraine, E-mail: astdept@astrophys.ups.kiev.ua)
O.I.Maksimenko (Institute of Geophysics, pr.Palladina, Kiev, Ukraine)

A cross correlation of thunderstorm observations, from data provided by the radiometer operated by the Materials Solar Radioservice (wavelength = 1.5m, and sensitivity approximately 10-22W/m2Hz), and ionospheric station data about sporadic E-layers has been conducted. The results of this study show that sporadic E-layers and thunderstorms occurred simultaneously on 69 occasions from a sample of 100 thunderstorms examined. The dynamics of sporadic E-layer are in good agreement with thunderstorm activity. Results of a statistical analysis demonstrate the existence of a complex thunderstorm - E-layer interaction. It is suggested, that thunderstorms may be one of the mechanisms of sporadic layer formation, which can explain a number of observed characteristics of E-layers.

COORDINATED SIMULTANEOUS FREJA - NIEMEGK ULF MEASUREMENTS

K. Prikner (Geophysical Institute, Academy of Sciences of the Czech Republic, Boční II/1401, 14131 Praha 4 - Spořilov, Czech Republic)

The standard FFT analysis was applied on the thirteen pulsation events selected from the March-April 1993 measurements. The two principal subjects were treated: a) The frequency - amplitude satellite - ground relations. Average values of the spectral amplitude transmission coefficients in the total Pc4-3 and, separately, in Pc4 and Pc3 bands were 0.60, 0.48 and 0.70, respectively. The transmissivity maxima were near f≈30 mHz. b) Estimation of bands of the field line resonances (FLR) on Freja. The Freja latitude motion ($\tilde{}\pm5^{o}$ around Niemegk) during measurements caused, the two harmonics of FLRs with 10's of mHz bands were identified on Freja (2nd predominant). The 1st harmonics mostly vanished at Niemegk. The weighted frequencies $f_{w1}\approx$ 18 mHz, $f_{w2}\gtrapprox$36 mHz with the fine structure separations about 4 mHz and 5 mHz, respectively.

MODELING THE IONOSPHERIC RESPONSE TO TRAVELING ATMOSPHERIC DISTURBANCES

G.W. Prölss (Institut für Astrophysik, Auf dem Hügel 71, 53121 Bonn, Germany
R. Bauske (Space Physics Research Lab., University of Michigan, Ann Arbor, USA

Anomalous increases of the ionization density at middle latitudes (positive ionospheric storms) belong to the prominent features of upper atmospheric storms. One of their possible causes are traveling atmospheric disturbances (TADs) which propagate from polar to equatorial latitudes, carrying along equatorward-directed meridional winds of moderate magnitudes. At middle latitudes, these winds cause an increase in the height of the F2 layer which in turn will lead to an enhancement of the ionization density. Using a simple description of a TAD and an ionospheric model, we are able to reproduce the basic properties of such perturbations. We also attempt to simulate an actually observed storm period. Rough agreement is obtained when the wind speed is derived from the height of the F2-layer peak. A more detailed simulation of the initial phase of the storm requires a more refined TAD model with time-dependent height gradients in the wind field.

USE OF THE WISCONSIN H-ALPHA MAPPER (WHAM) FOR THE STUDY OF GEOCORONAL BALMER-ALPHA

F.L. Roesler and S. Nossal (Dept. of Physics, Univ. of Wisconsin, Madison, Wisconsin 53706 USA)
R. J. Reynolds (Dept. of Astronomy, Univ. of Wisconsin, Madison, Wisconsin 53706 USA)

The Wisconsin H-alpha Mapper (WHAM) is a remotely operable facility for night-sky emission line observations. An all-sky siderostat feeds a double 150mm etalon Fabry–Perot spectometer coupled to a CCD camera. The Fabry–Perot interference pattern is imaged onto the CCD camera and converted to a line profile using an annular summing method. It will be used at the Kitt Peak Observatory near Tuscon, Arizona principally for making quantitative velocity–resolved, all–sky maps of the Balmer–α emission from the interstellar medium [Reynolds, work in progress]. A portion of the WHAM observing time will be optimized for exospheric emission studies. A large amount of additional geocoronal data will be extracted from the galactic profiles, which, on average, are centered about the narrow, and usually dominant, geocoronal feature. The instrumental resolution ($\sim$ 25,000) provides good isolation of the geocoronal feature. Accurate intensity calibration is provided by astronomical nebular sources. A signal to noise ratio of over 50 is achieved in a 30 sec exposure for a typical 3R geocoronal line. The data will be examined for diurnal, seasonal, solar–geophysical, and solar cyclical variations. Investigation of these variations will facilitate isolating long term trends that might arise from climatic effects.

STUDY OF HF PLASMA TURBULENCE EVOLUTION WITH HIGH TEMPORAL RESOLUTION USING STIMULATED ELECTROMAGNETIC EMISSION.

E.N. Sergeev, V.L. Frolov (Radiophysical Research Institute, Russia)

An overview of new experimental results concerning the temporal evolution of various spectral features of the stimulated electromagnetic emission (SEE) generated by HF wave-plasma conversion in the ionosphere are presented. The measurements of the SEE evolution with high time resolution ($\sim$ 0.3 ms) have been performed by the SURA heating facility using various frequencies (f_{PW}), effective radiated powers (ERPs, including D-region absorption) and on/off times (τ_{on}, τ_{off}) of pumping. To study the SEE evolution under "cold start" conditions the low duty-cycle pulsed HF transmissions with $\tau_{on} \sim$ 15–200 ms $\ll \tau_{off} \sim$ 1–10 s are used. It has been found that the growth of the SEE intensity up to it's maximum within $\tau_{max} \sim$ 1–50 ms and following overshoot are observed along with the development of the strong suppression of the pump wave. Here the larger times correspond to both more downshifted SEE frequencies ($\Delta f = f_{SEE} - f_{PW} < 0$) and lower ERP. For ERP* < 5–20 MW the SEE intensity is decreased with e-folding decay time $\tau_d \simeq$ 4–5 ms after the pulse turn off. The value of ERP* increases with reducing τ_{on} from 200 ms to 15 ms. The decay time is substantially decreased (up to $\tau_d(\Delta f) \simeq$ 0.7–2.0 ms) with increasing the power up to 60–75 MW ERP. The decrease of the decay time up to 1.5 times with the overshoot development is observed. The data presented are compared with our previous measurements in the high perturbed ionosphere as well as with radar observations of ionospheric langmuir turbulence over Arecibo. To explain the HF plasma turbulence evolution the mechanisms of the wave-plasma energy transfer over the spectrum and collisionless damping are invoked.

EXPERIMENTAL TOMOGRAPHY RESEARCH ON TRANSECT MOSCOW-ARKHANGELSK

Razinkov O.G., Ruzhin Yu.Ya., Shagimuratov I.I. (IZMIRAN, Troitsk-town, Moscow,142092, RUSSIA)

The Moscow-Arkhangelsk transect represents by self interest from the scientific point of view: it crosses the area of main ionospheric trough (MIT), which in last years was actively investigated on the base of observatory triangle of Arkhangelsk geophysical ground of IZMIRAN. Close to a new line cosmodrom PLESETSK is located. In case of rocket start on orbits with inclination of 81° -83° the trajectories of a rocket with a working engine in the ionosphere dynamo-region coincides with tomographic section and thus provides a unique opportunity of diagnostics of ionosphere processes, occurring owing to start. Advantages of a given region are shown and results of research of artificial substorm, stipulated by start of low-powered rocket are presented . It is shown, that in quite magnetic conditions MIT is usually located in the afternoon very close to high latitudes (the minimum plasma density should be moved up to 74° at 14 :00 LT) but in our case (26.05.93) the trough is located southward of Arkhangelsk on latitude smaller than 62°. A remarkable feature of a discussed trough of plasma density is its inclination to horizon of about 45° but it is known that MIT is usually located vertically. Similar tomographic experiments, conducted at the end of 1993 during Russian-American Tomography campaign with simultaneous Millstone Hill radar measurements have confirmed existence such "slant " structures on the same geomagnetic latitudes. The preliminary mathematical modeling on the basis of well known ionospheric models does not permit to receive such experimentally observable structures. The good accuracy of a phase-difference tomography method is confirmed by the comparison of N(h) - profiles obtained by Moscow and Arkhangelsk vertical sounding equipment and by radiotomography. The tomographic section constructed by use of experimental data of two ionosondes did not practically differ from that constructed by purely a radiotomographic method.

The EISCAT Svalbard Radar: Status, First Observations and Scientific Perspectives

J. Röttger, U.G. Wannberg, I. Keskitalo, I. Wolf (EISCAT, Kiruna, Sweden)
J.A. Hansen, R. Hund (EISCAT, Tromsø, Norway)
A. Huuskonen (FMI, Helsinki, Finland)
J. Markkanen, M. Postila (EISCAT, Sodankylä, Finland)

The EISCAT Svalbard Radar (ESR) was constructed by the EISCAT Scientific Association as an extension of the existing EISCAT incoherent scatter radars in northern Scandinavia. The ESR will be used to study ionosphere-thermosphere coupling processes in the region of the magnetospheric cusp and the polar cap.

This radar became operational in March 1996 and data were recorded covering F-region altitudes. We present the basic radar operation scheme, the validation of acquired raw data and the results of the data analysis, displaying basic ionospheric parameters of electron density, electron and ion temperature and ion velocity in the magnetic-field aligned direction.

Preliminary scientific interpretations of the data validation and analysis results will be given, showing short-term transients in the raw data spectra and a marked variability in the basic ionospheric parameters, respectively. We also describe the planned operations of the EISCAT Svalbard Radar for high-latitude research.

MIDDLE LATITUDE MEASUREMENTS OF TEC USING GPS OBSERVATIONS

I.I. Shagimurator and I.I. Jephishov (West Department of the Institute of Geomagnetism, Ionosphere and Radiowave Propagation (I2MIRAN) of the Russian Academy of Sciences, Pobeda Str. 41, 236017 Kaliningrad, Russia)
L.W. Baran (Institute of Geodesy, Olsztyn University of Agriculture and Technology, Oczapowski Str. 1, 10957 Olsztyn, Poland)

Preliminary results of TEC measurements using GPS observations are presented . The observations were performed with Turbo Rogue GPS receivers at the IGS stations in Poland. The ionospheric studies have been carried out since 1995 by West Department of the I2MIRAN (Russia) jointly with the Institute of Geodesy of the Olsztyn University of Agriculture and Technology (Poland). The instrumental biases and TEC have been computed from GPS observables using the ionospheric model for diurnal variation of ionospheric delays. It has been shown, that accurate results of instrumental biases determination can only be achieved if ionosphere is not disturbed. In storm time the error in TEC determination, because of incorrect bias, may be more than $2\times10e^{16}$ el/m^2. TEC has been computed separately on the phase and code measurements. The accuracy of the absolute TEC estimation obtained from the phase measurements is approximately equal to those the code data. During minimum solar activity at middle latitudes, the TEC values are evaluated as lass than $2\times10e^{17}$ el/m^2. The ratio of maximum to minimum seasonal TEC values is of order of 1.4 ÷ 1.6 In report the storm time changes of TEC and these a comparison with the variation of $(fo\ F2)^2$ are presented. The comparison GPS TEC measurements with the IRI model are also discussed.

IONOSPHERIC VARIABILITY AT FIXED HEIGHTS.

J. G. Solé, D. Altadill (Observatori de l'Ebre, 43520 Roquetes, Spain)

One year of hourly electron density profiles obtained from digital ionograms recorded at Observatori de l'Ebre has been used to study the ionospheric variability at fixed heights.
For each hour and month, the Averaged Representative Profile has been calculated in order to determine a typical profile, and four parameters as indicators of the variability are considered: upper and lower deciles, standard deviation (σ) of the electron density (N), and relative variability (V) defined as σ divided by N.
We found that the dispersion and σ increase with altitude, σ has a maximum around midday and V shows the opposite behaviour.
The seasonal variation for the considered parameters at fixed heights is the following: N displays a winter anomaly, better expressed at higher altitudes, σ shows a maximum near solstices and minimum near equinoxes, and V has the same behaviour as σ during day time, but it changes at nitght.

THE IMPEDANCE PROBE IN THE PROJECT DEOS

C.T. Steigies, D. Block and A. Piel (Institut für Experimentalphysik, Christian-Albrechts-Universität Kiel, Olshausenstr. 40-60, D-24098 Kiel)

In the project DEOS three sounding rockets will be launched from southern India to study the diurnal variation of the dynamics of the E- and F-layers at the edge of the equatorial electrojet. Plasma diagnostics are performed with in-situ measurements (Langmuir probes, Resonance cone probes, Impedance probes) and integral measurements (TEC measurement with Radio Beacon). For comparison, ground based techniques (ionosondes, magnetograms, VHF radar) will be employed. The new impedance probe uses digital frequency synthesis and allows for a good spatial resolution (130 m) together with high accuracy (1.5%) due to the fast sweep time of the instrument. The properties of this instrument will be presented in terms of measurements performed in a large plasma tank. It will be shown which steps have to be taken for an instrument that is suitable for future satellite application and will have "built-in intelligence" to provide absolute plasma densities at a greatly reduced data rate.

LIGHTNING RELATED HEATING, BREAKDOWN AND VLF FIELDS IN THE LOWER IONOSPHERE

A.I. Sukhorukov and P. Stubbe (Max-Planck-Institut für Aeronomie, D-37191 Katlenburg-Lindau, Germany)
E.A. Rudenchik (Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, 142092 Troitsk, Moscow Region, Russia)

Lightning electromagnetic pulse penetration into the night-time low ionosphere and plasma modification are simulated using both large particle method and fluid approach. The large particle method is developed for a correct description of the dynamics of a strongly non-equilibrium weakly ionized plasma in the front of the pulse. The collisions of the electrons with the neutral species, both elastic and related to the excitation, ionization of and attachment to the neutrals are modeled using the Monte-Carlo technique. The simulations confirm recent findings of impulse electron heating up to a few eV and large induced ionization in the lower ionosphere above the strong lightning discharge. For a single discharge with a large return stroke current, the model shows the possible increase of the electron density at altitudes about 83 – 90 km by hundreds of percent and more, depending on the amplitude, form and duration of the incident electromagnetic pulse. The selfconsistent VLF fields on the time scale of 100 μs are subjected to strongly nonlinear damping during the passage through the D-region of the ionosphere.

POSSIBLE CAUSES OF LARGE QUASI-DC ELECTRIC FIELDS IN THE IONOSPHERE ABOVE ATMOSPHERIC WEATHER SYSTEMS

A.I. Sukhorukov and P. Stubbe (Max-Planck-Institut für Aeronomie, D-37191 Katlenburg-Lindau, Germany)

Satellite observations of very large quasi-dc ionospheric fields have been recently reported and attributed to large-scale atmospheric weather formations. The problem is that the measured fields are by one – two orders of magnitude larger than maximally predicted by existing theories. We discuss possible causes and consider, among others, the mechanism of nonlinear ULF excitation due to high-altitude flashes. Indeed, recent discoveries of "elves", "red sprites" and "blue jets" revealed the possibility of a much stronger lightning coupling to the ionosphere than previously deemed possible. It has become apparent that strong tropospheric lightning discharges cause significant electron heating in the night-time lower ionosphere and may lead to the breakdown in the D-region. These transient processes, associated with large high-altitude nonlinear currents, can strongly enhance the weight of the ULF-ELF spectrum in the lightning transients in the ionosphere and in the radio atmospherics propagated in the Earth-ionosphere waveguide. In this paper, the effect of the ionospheric Alfven resonator excitation by strong, elves-producing tropospheric discharge will be considered in more detail.

ROCKET INVESTIGATIONS IN THE EQUATORIAL-LOW LATITUDE REGION FOR DIFFERENT DIURNAL CONDITIONS DURING EQUINOX

H.Thiemann (Arbeitsgruppe Weltraumphysik und Technologie, Salzstr.33, D-79098 Freiburg, Germany)
S P.Gupta (PRL, Ahmedabad-380009, India), G. Mayer (DLR, D-82234 Oberpfaffenhofen, Germany and A. Piel (Kiel University, D-24098 Kiel, Germany)

The DEOS-project represents an investigation of the Dynamics of the Equatorial ionosphere Over SHAR, a launch site, which is slightly offside the equatorial electrojet. Three Rohini RH-560 rockets will be launched for specific diurnal conditions. Evening, night and noon hours for launching have been defined to meet characteristic ionospheric anomalies in the equatorial region like prereversal current enhancement, equatorial Spread-F and sporadic-E effects. The particular sequence is selected in order to obtain reliable predictions during afternoon and early evening hours for Spread-F conditions in the forthcoming night. The rockets, which will be launched in eastward direction, are designed to reach an apogee of around 500 km. The instrumentation of the scientific payload includes Langmuir probes, an impedance probe, resonance cone and radio beacon antennae as well as a precision magnetometer and provides measurements of the essential plasma parameters with a spatial coverage of different scale sizes. The expected plasma conditions prevailing during the launch times will be presented as a first order estimate in terms of available ground-based measurements from relevant Indian ground stations Anticipated in-situ results will be assessed in terms of previous rocket experiments and in the light of the predictions from empirical ionospheric models.

SMALL-SCALE MODELLING THE PENETRATION OF THUNDERCLOUD ELECTRIC FIELDS INTO LOW LATITUDE IONOSPHERE

P.T.Tonev and P.I.Y.Velinov (Central Solar-Terrestrial Influences Laboratory, Bulgarian Academy of Sciences, Acad. G.Bonchev Str., Block 3, Sofia 1113, Bulgaria)

Electric fields **E** produced by thunderclouds and lightning couple much energy into the middle atmosphere and ionosphere, mainly in the ELF-ULF range. Several models analyze these fields and also their ionospheric effects. However most of them assume vertical geomagnetic field lines, i.e. the high-latitude case. We consider the much more important low-latitude case, where the main part of global thunderstorm activity is concentrated. A numerical model based on the Maxwell equations in DC approximation is proposed by which the fine structure of the field **E** in the ionosphere is investigated. The model uses the finite element method. Results obtained shows that the zonal component of **E** is big enough to cause plasma irregularities, mainly in *E*-region. The probable effect of **E** on the electron density in the ionosphere (due to plasma redistribution processes) is analyzed in first-order apporoximation.

COMPARISON OF O^+/H^+ AND $O^+/(H^+ + He^+)$ TRANSITION LEVELS

L. Třísková, V. Truhlík, J. Šmilauer, (Institute of Atmospheric Physics, 141 31 Praha 4, Czech republic)

Yu.A. Shultchishin (Space research Institute, Profsoyuznaya 84, 117810 Moscow, Russia)

The upper transition height where prevailing ionized component changes from O^+ to light ions has been studied. Previous results for O^+/H^+ transitions in solar maximum are completed considering the possible He^+ dominance.

Data from mass spectrometer of the Bennet type and from Retarding Potential Analyzer onboard the Intercosmos 24 satellite (Project ACTIVE - perigee 500 km, apogee 2500 km, inclination 83°) has been processed for the period winter 1989-spring 1991.

A LOW-LATITUDE EMPIRICAL MODEL OF ELECTRON TEMPERATURE BETWEEN 500 AND 3000 km IN SOLAR MAXIMUM

V. Truhlík, J. Šmilauer, L. Třísková (Institute of Atmospheric Physics, 141 31 Praha 4, Czech republic)

V.V.Afonin (Space research Institute, Profsoyuznaya 84, 117810 Moscow, Russia)

Data measured by Radiofrequency Probe and Retarding Potential Analyzer onboard the noncircularly orbiting satellites Intercosmos 19, 24 and 25 covering heights between 500 - 3000 km and maxima of solar cycle 21 and 22 has been employed to construct partial models depending on invariant latitude, longitude, local time, and geomagnetic activity. Selected magnetic storms are analysed, the development of measured and modelled electron temperature is compared.

ANALYSIS THE EFFECT OF MACROSCOPIC AND MICROSCOPIC PROCESSES IN THE IONOSPHERIC *F*-REGION USING A MODIFIED KINETIC BOLTZMANN EQUATION

P.I.Y.Velinov, P.T.Tonev and B.N.Dimitrov (Central Solar-Terrestrial Influences Laboratory, Bulgarian Academy of Sciences, Acad.G.Bonchev Str., Block 3, Sofia 1113, Bulgaria)

A new modified kinetic Boltzmann equation for the thermosphere - ionosphere system has been proposed. In this equation the influence of macroscopic (diffusion, ionization and attachment) as well as microscopic (interaction between particles) processes on the electron distribution function $f(t,\mathbf{r},\mathbf{p})$ are taken into account. This equation is transformed in a new one using Laplace transformation method. Numerical results for the initial equation are then achieved after solving the transformed equation. The following moments for the electron distribution function are also derived: (a) the zero moment, representing the electron density distributon $N(t,\mathbf{r})$; (b) the first moments - the components of the macroscopic velocity $\mathbf{V}$; (c) the second moments, containing the components of the tensor of density impulse flow and (d) the third moments, containing the heat transfer tensor. An analysis of the energy and momentum budget of the thermo/ionosphere has been performed and an emphasis is put on the vertical coupling under quiet and disturbed conditions from above (magnetosphere-ionosphere interactions during SSC) and from below (atmospheric disturbances).

MODELLING THE 11-YEAR COSMIC RAY VARIATIONS IN THE IONOSPHERIC D-REGION

P.I.Y. Velinov and L.N.Mateev (Central Solar-Terrestrial Influences Laboratory, Bulgarian Academy of Sciences, Acad. G. Bonchev Str., Block 3, Sofia 1113, Bulgaria)

H. Ruder and U. Zellhuber (Institute for Astronomy and Astrophysics, University of Tuebingen, Auf der Morgenstelle 10, 72076 Tuebingen, Germany)

The galactic cosmic rays (GCR) are an essential factor for the ionization state in the region 0-80 km of the Earth environment. In the mesosphere (55-80 km) they form an independent cosmic ray layer which is situated in the lower part of the ionospheric *D* - region. In the present work is proposed an improved model for the GCR ionization there. In all models until now the differential energetic spectrum of GCR was presented as a simple power function. Here we propose a generalized spectrum for the most important for the ionosphere energy interval III : 3.10^{-2} - 3.10^{-2} GeV/nucl. The differential spectrum peak is situated between the energies (3-6).10^{-1} GeV/nucl. The generalized spectrum has three parameters which are determined by means of solving the nonlinear equation system by the Newton iteration method. In the work are obtained results for the differential energy spectra of primary protons and another groups of nuclei from the GCR composition. The spectra are calculated for different levels of solar activity: solar minimum, average solar activity and solar maximum. The so obtained generalized spectrum presents well the 11-year variations of GCR, which modulate the ionization state and the electrical parameters of the ionosphere-atmosphere system. These GCR spectra are applied for the computation of the electron production rate profiles and electrical conductivity profiles in the middle atmosphere and lower ionosphere.

ELECTRODYNAMICS OF SIMPLE ARCS DRIFTING EQUATORWARD FROM THE POLAR CAP

P.J.S.Williams, C. del Pozo and I.Hiscock (University of Wales, Aberystwyth SY23 3BZ Wales)

EISCAT measurements of electron concentration, electron and ion temperature, Pedersen and Hall conductivities, electric field and neutral wind, and optical measurements of the morphology, intensity and position of an auroral arc can be combined to give the full electrodynamics of the arc. In order to make an unambiguous interpretation of the data this paper concentrates on the study of simple arcs, which drift steadily equatorward from the polar cap for several minutes without any major change in appearance, rather than the most dynamic auroral events associated with substorm onset, where major changes occur on a time scale shorter than the time resolution of the EISCAT radar. Using the complete data-base over a period of 9 years it is possible to select many examples of such simple arcs, mostly associated with the growth or recovery phase of the substorm cycle. In each case it is possible to measure the band of enhanced electric field strength adjacent to the arc, and the corresponding distribution of Pedersen and Hall currents. It is also possible to compare the average convection velocity measured by EISCAT and the drift velocity of the optical feature. From this data set we derive the typical electrodynamics of a simple auroral arc, as it is carried equatorward by convection.

IONOSPHERIC VECTOR VELOCITIES BY DYNASONDE AND EISCAT: METHODS FOR COMPARISON AND RESULTS

J. W. Wright, T. S. Virdi and P. S. J. Williams; Dept. of Physics, University of Wales,.Aberystwyth; Wales, UK

It is widely recognized that ionospheric velocities by ionosonde (total reflection) methods do not have a unique physical interpretation. Nevertheless, there are compensations including economy, locally wide spatial coverage, good S/N, temporal continuity, and resolution. Not least, an additional feature is a diversity of available physical interpretations which depend on ionospheric conditions and data analysis strategies. Almost exactly the opposite of each of these considerations applies to the ISR method of EISCAT. Thus there are strong incentives to refine the ionosonde methods, and to compare them with EISCAT's unambiguous measurements of ion velocity. In this paper we concentrate on comparing the two experiments as techniques for measurement of ionospheric electric field. The field is a vector or complex quantity, simply related (for EISCAT) to the velocity vector normal to the geomagnetic field in the F-region. It is appropriate and revealing to compare time series' of vector velocities from the two experiments by the process of time-lagged complex cross-correlation. Correlation magnitudes exceeding 0.7 are found in some conditions. Complex interpolation is required in data gaps. We show results of a new strategy for dealing with the case of spatially-varying velocities within the dynasonde field of view.

A STUDY OF THE CORRELATION OF TRAVELLING IONOSPHERIC DISTURBANCES; A NEW TECHNIQUE.

A.F. Yakovets, V.I. Drobjev, M.Z. Kaliev, V.V. Vodyannikov
(Institute of Ionosphere, Academy of Sciences, Almaty, Republic of Kazakstan).

Recent studies, using Doppler sounding of the ionosphere have made it possible to determine the spatial and temporal structure of travelling ionospheric disturbances (TIDs). It is found that TIDs are superposition of a continuous stochastic field and restricted in space and time quasi-deterministic TIDs packets. This paper reports a technique of a separation TIDs packets from the background stochastic field. A multi-frequency Doppler sounding gave experimental records used at the technique. The treatment of numerous records revealed large distinction of features of the TIDs packets and the background field. For example the TIDs packets propagate practically without change over significant distances but a coherence of the background field decreases rather fast.

NONLINEAR INTERACTION OF KINETIC ALFVEN WAVES AND IONIC ACOUSTIC WAVES IN THE IONOSPHERE.

A.K.Yuchimuk (Dept. of space plasma Physics, Main Astronomical Observatory NASU, 252650, Kiev, Goloseevo,Ukraine)
V.N.Fedun, O.G.Falko (Dept. of Physics Kiev University, p. Glushkova 6, 252022 Kiev, Ukraine)

In present paper we study nonlinear parametric interaction of kinetic Alfven waves and ionic acoustic waves in a magnetoplasma. A nonlinear dispersion equation for the coupling waves, the growth rate are found using two-fluid MHD. The growth rate of the instability proportional to electron inertial length. Therefore, founding parametric process can occur in case when effect of electron inertial length in Alfven waves is taken into account. At present theoretical results could be useful for interpretation of the nonlinear processes in the ionospheric and space plasma. In particularly, received data on "Freja" satellite pointed to connection between Alfven and ionic acoustic waves. In this case observed electromagnetic turbulence is interpreted as kinetic Alfven waves with perpendicular wave length of the order of electron inertial length.

IONOSPHERIC CONVECTION AND NEUTRAL WINDS: TIME-DEPENDENT COUPLING

V.E. Zakharov and N.M. Kaschenko (Department of Physics, University of Kaliningrad, Kaliningrad, 236041, Russia)

The ionospheric disturbed dynamo influences strongly the ionospheric convection pattern. Some time-delay is present before the neutral atmosphere winds are intensified after the beginning of geomagnetic storm. The purpose is to investigate self-consistently dynamics both of ionospheric convection and thermospheric winds under disturbed conditions. To this purpose, our numerical model worked out to describe the steady ionospheric convection is generalized. This is done by including of the momentum equations employed for thermospheric winds together with the equations describing the electric field and the ionospheric conductivity in analysis. A conjugacy effect between the ionospheres of northern and southern hemispheres is taken into account. To this purpose, a method of the equivalent current source is used with respect to the field-aligned currents flowing between the ionosphere and the magnetosphere. The storm-type enhancement is given to modify the initial patterns of the equivalent current source and of the fluxes of the energetic electrons precipitating from the magnetosphere into the ionosphere.

INVESTIGATING AND PREDICTING OF CRITICAL-FREQUENCY VARIATIONS IN THE MIDLATITUDE IONOSPHERE F2-REGION

Zakharov I.G., Tymov O.F. Kharkiv State University, Kharkiv, Ukraine

There were investigated day-to-day critical-frequency variations in the midlatitude ionosphere F2-region (dfoF2), caused by the solar and geomagnetic activities. It is shown that in order to predict these variations, one should use the dfoF2-values for 03, 09, 15 and 21 LT and special geomagnetic-activity index which characterizes a middle activity level over time-intervals not smaller than 9 hours, which - as a rule - refer to evening and night hours. Such an approach allows to take into consideration seasonal and diurnal features of energy coming from the auroral into the midlatitude ionosphere.

INFLUENCE OF SPRING STRATOSPHERIC CIRCULATION TRANSITION ON SPORADIC LAYER E

E.Yu.Zykov, O.N.Sherstyukov, A.D.Akchurin
Kazan State University, Lenin st., 18 , Kazan, 420008, Russia

Data for 32 years of ionospheric dates for 8 midlatitude station of European region of Russia (50-60°N, 20-100°E) was used in work. The dependence of the Es-layer intensity in summer period on the beginning of spring seasonal transitions of zonal circulation (STC) in stratosphere was found.
The comparative analysis of STC-terms on isobaric of a surface 10 mbar and intensity of the Es-layer (monthly average values $\delta f_0Es = f_0Es - f_0E$ of excess of sporadic ionization over background) was shown:

- The interannual variations of intensity of summer Es-layer occur according to the changes of beginning of STC in stratosphere, thus the greatest influence of the date of STC on the Es-layer was observed in May-July, excepting for August.
- In year with early transitions of circulation the Es-layer intensity raises in factor 0.72 than in late transition years.

ST4 Open session on the magnetosphere

Convener: Rycroft, M.J.

ULF COMPRESSIONAL WAVES IN THE DAWN AND DUSK MAGNETOSPHERE REGIONS FROM THE INTERBALL TAIL PROBE DATA

Agapitov A.V.[1], Fedun V.N.[1], Grushin V.A.[2], Ivchenko V.N.[1], Klimov S.I.[2], Leonov N.A.[1] and Verkhoglyadova O.P.[1]
[1] Dept. of Astronomy and Space Physics, Kiev University, Vladimirskaya 64, Kiev 252033, Ukraine
[2] Space Research Institute, Profsoyuznaja, 84/32, Moscow 117810, Russia

Plasma waves in the dawn and dusk magnetosphere regions near the geomagnetic equator plane are studied. Experimental data obtained by Interball Tail probe are analysed for the time period from October 1995 through January 1996. Spectral characteristics of compressional type waves in the frequency range of Pc3 - Pc5 pulsations are obtained. Method for identification of type of the low frequency wave events is used. Anti-phase correlations between the magnetic and plasma pressures in high-beta plasma environment are analyzed. Possible generation mechanisms for these wave events are discussed.

AZIMUTHAL PLASMA PRESSURE GRADIENTS AND THEIR ROLE IN AURORAL DYNAMICS

E. E. Antonova and **N. Yu. Ganushkina** (Scobeltsyn Institute of Nuclear Physics, Moscow State University, Moscow, 119899, Russia)

The evaluations of the role of azimuthal plasma gradients in the high latitude auroral magnetosphere have shown that they can support not only Region 2 field-aligned currents as it was suggested in many studies but also Region 1 currents. Such gradients are automatically arise due to the geometry of high latitude magnetospheric trap that provides the noncoincidence of the current lines and the magnetic flux tube volume isolines. Arising due to existing azimuthal plasma pressure gradients Region 1 currents close in the ionospheric dynamo region and create dawn-dusk electric field in the polar cap. The stability of picture is explained by action of medium scale electric field harmonics in the plasma sheet. The theory makes possible to explain some features of magnetosphere substorm dynamics. During substorm growth phase the increase of the near-Earth tail current must bring to the magnetic flux tube volume isoline stretching antisunward. As a result the azimuthal plasma pressure gradients and so Region 1 currents must increase. Under the condition of slow variations of ionospheric conductivity such increase brings to the dawn-dusk electric field increase. During substorm expansive phase when the near-Earth tail current is disrupted, the magnetic flux tube volumes in the region of dipolarization are greatly increase. So in spite of the particle acceleration, the local pressure hole is formed. On the bordersof this hole large azimuthal plasma pressure gradients are created and substorm current wedge is formed.

STORM-TIME EROSION OF THE DAYSIDE MAGNETOSPHERE

A.A.Arykov, Yu.P.Maltsev
(Polar Geophysical Institute, Apatity, 184200, Russia)

The standoff distance can be determined from the pressure balance condition on the magnetopause: $(2\mu_o p_{st})^{1/2} = B_z^{dip} + B_z^{RC} + B_z^{Birk} + B_z^{TC}$, where p_{st} is the solar wind pressure in the stagnation point; the right-hand side of this equation is the sum of the magnetic fields of the Earth's dipole, of the ring, Birkeland, and cross-tail currents, respectively, all the fields being shielded by the magnetopause currents. The equation for the standoff distance is analyzed for various conditions. Region 1 Birkeland current is responsible for the erosion of the dayside magnetosphere under moderate geomagnetic activity. Contribution of the cross-tail current to the storm time erosion appears to be dominant. It is shown that the influence of the cross-tail current on the standoff distance during intense storms can be more considerable than that of the solar wind pressure.

LOW FREQUENCY WAVES IN MAGNETOSHEATH

M.A. Balikhin, H. St. C. K. Alleyne and S. N. Walker (Space Instrumentation Group, Department of Automatic Control and System s Engineering, University of Sheffield)
M. Dunlop and W.A.C. Mier-Jedrzejowicz (Department of Physics, Imperial College of Science, Technology and Medi cine)
W. Baumjohann (Max Planck Institut für Aeronimie, Garching bei Munchen)

Low frequency turbulence in the Earth's magnetosheath is studied using AMPTE UKS and AMPTE IRM magnetic field data. A method based on the local wavenumber concept was used to determined the plasma modes of observed waves. The compositi on of the low f requency magnetosheath turbulence has been subjected to statistical study to de termine its dependence upon plasma parameters in that region.

MAGNETOSPHERIC SOUNDING BY MIDDLE FREQUENCY WAVES

D.V. Blagoveshchensky (Academy of Aerospace Instrumentation Bolshaya Morskaya 67 St.Petersburg 190000 Russia)
O.A.Maltseva (Institute of Physics Stachky Str 194, Rostov-on-Don 344090 Russia)

Our previous results showed that the main ionospheric trough(MIT) could behave as a channel for middle waves (Abstracts of XXV Assembly, URSI, 1996,p.733). This fact is confirmed by the observations of echo-signals and the ray tracing simulation of the magnetospheric propagation of 1.5-4MHz waves. The comparison between theory and experiment was fulfilled with respect to the time delay Tgr of one jump through the conjugate hemisphere.New thorough calculations show that MIT-channel can be responsible for echo-signals like LDE with t>Tgr,in particular, with t=n* Tgr. The propagation conditions of such signals are connected with lowering of a channel depth along the MIT-magnetic field line. Values Tgr can be used as a tool of channel structure diagnostics.

ELECTRON-CYCLOTRON HARMONICS OBSERVED BY MAGION-4 SUBSATELLITE IN THE PL ASMA SHEET

J.Blecki (Space Research Centre, Polish Academy of Sciences, Bartycka 18A, 00-71 6 Warsaw, Poland)
J.Juchniewicz, K.Kossacki, R.Wronowski (Space Research Centre, Polish Academy of Sciences, Warsaw, Poland)
S.I.Klimov, S.A.Romanov, S.P.Savin (Space Research Institute, Moscow, Russia)
P.Triska, J. Smilauer (Institute of Atmospheric Physics, Praha, Czech Republic)
Z.Nemecek, J.Safrankowa (Charles University, Praha, Czech Republic)
J.A.Sauvaud (CESR, Toulouse, France)

During few crossings of the near to the Earth plasma sheet at the flank of the m agnetosphere , by Magion-4 subsatellite to Interball -tail probe, the magnetic c omponent of plasma waves in the frequency range 32-2000Hz was measured. The in creasing of the wave activity was seen within the plasma sheet, particularly strong during dist urbed time. The characteristic emissions were associated with harmonics of the e lectron - cyclotron frequency up to 5th order. These modes of plasma waves can be generated by anisotropy of the electron temperature or by so called ring distribution functi on of electrons. Discussed region of the magnetosphere is thought to be very imp ortant for the substorm developing. There are often observed electrons with anis otropy of the t emperature. In our presentation we will discuss observed wave spectra together w ith electron spectra in the relation to the possible generation mechanism of ele ctron- cyclotron waves.

STRONG ACCELERATION OF PROTONS AND HEAVY IONS IN THE MAGNETOTAIL: THEORY AND OBSERVATIONS

J. Büchner, J.-P. Kuska, B. Wilken and Q. Zong (Max-Planck Institut für Aeronomie, Max-Planck Str. 2, D-37191 Katlenburg-Lindau, Germany FR)

Observations by the time-of-flight devive HEP-LD onboard GEOTAIL have revealed the presence of energetic O^+ ions in the distant magnetotail. Since the source of O^+ is obviously the ionosphere, ejecting cold particles, the observed higher energies are achieved, perhaps, by acceleration in reconnection induced electric fields. As we recently have shown, in this case the acceleration is strong enough to cause a pickup process. Based on our theory of strong acceleration in magnetotail-like fields we model the spectra of oxygen and helium ions as well as of protons. We verify the model predictions by means of particle simulations. Comparing modeled and observed spectra we can show that the different spectra for heavy ions and protons can be well explained by the pickup theory of strong acceleration.

LOW FREQUENCY WAVES DOWNSTREAM OF THE EARTH'S BOW SHOCK

A. Czaykowska, T. M. Bauer, W. Baumjohann and R. A. Treumann (Max-Planck-Institut für extraterrestrische Physik, D-85740 Garching, Germany)

We analyze plasma and magnetic field data from 132 crossings of the Earth's bow shock by the AMPTE/IRM spacecraft. We concentrate on the region from the bow shock to about 10 minutes downstream where we examine the low frequency magnetic fluctuations up to 2 Hz. The shape of the spectra does not change across the quasi-parallel bow shock (angle between the interplanetary magnetic field and the shock normal vector $\vartheta_{Bn} < 45°$) and therefore the magnetic fluctuations are thought to be convected downstream from the upstream region. This agrees well with the fact that in the downstream region no proton temperature anisotropy is found, which might act as a source of free energy. Downstream of the quasi-perpendicular bow shock ($\vartheta_{Bn} > 45°$) a large proton temperature anisotropy ($T_{p\perp} \gg T_{p\parallel}$) is observed. Such unstable particle distributions can generate left-hand polarized ion cyclotron waves and mirror mode waves. We find a dominating left-hand polarized mode at frequencies below the proton cylotron frequency downstream of the low-β bow shock ($\beta < 0.5$, with β the ratio of thermal to magnetic pressure), whereas mirror-like fluctuations are often evident downstream of the high-β bow shock ($\beta > 1.0$). These waves provide an important part of the dissipation at the quasi-perpendicular bow shock.

SPATIAL DISTRIBUTION OF 0.04-1 MEV ELECTRON FLUXES AT LOW L-SHELLS: THE RESULTS OF EXPERIMENT ON-BOARD MIR-SPECTR ORBITAL COMPLEX

A. V. Bogomolov, V. V. Bogomolov, Yu. I. Denisov, G. Ya. Kolesov, Yu. I. Logachev and S. I. Svertilov (Skobeltsyn Institute of Nuclear Physics, Moscow State University, Vorobjovy Gory, 119899 Moscow, Russia)
M. I. Kudryavtsev (Space Research Institute, Russian Academy of Science, Profsojuznaja st., 84/32, 117810 Moscow, Russia)

Since October, 1995 the experiment "GRIF-1" is carrying out on-board the module "SPECTR" of station "MIR" (the parameters of its orbit are: altitude 400 km, maximal latitude 51°). The complex of instruments "GRIF-1" includes the charged particle detector "FON-1" with small ($1cm^2 * sr$) geometrical factor, which allows to measure the variations of low electron fluxes in the regions closed to the geomagnetic equator. The higher fluxes of 0.04-1 MeV electrons were detected at L 1.3, 1.6 and 2.2. There are some indications that signable electron fluxes exist at L¡1.1. Obtained maps of electron spatial distribution at the altitude 400 km show the dynamics of electron fluxes for more than a year of observations.

3-D CURRENT SHEET DISRUPTION IN THE EARTH's MAGNETOTAIL: THEORY AND SIMULATION

J. Büchner and J.-P. Kuska (Max-Planck Institut für Aeronomie, Max-Planck Str. 2, D-37191 Katlenburg-Lindau, Germany FR)

At the onset of substorms the near Earth's tail current sheet disrupts and reconnection follows. For a long time the collisionless tearing mode instability (Coppi et al., 1966; Schindler, 1974) was the favoured mechanism of this disruption. Unfortunately, it has recently been ruled out on theoretical grounds and by numerical simulations. Consequemtly we have now carried out theoretical analyses and simulations of the three-dimensional sheet stability. Here we present first results for magnetotail initial conditions. Simulation results are discussed which have been obtained with our newly developed fully three-dimensional and kinetic electromagnetic particle-in-cell code GISMO. Theory and simulation show that in three dimensions current sheets decay, in contrast to the past two- dimensional results, after the sheet thickness has reached the ion inertial length. The three-dimensional sheet decay forms islands, which are limited in the current direction. Another distinctive feature of the three-dimensional sheet decay is the structured shear component B_z of the current sheet magnetic field.

A SIMPLE SCATTERING PARTICLE MODEL FOR DISSIPATIVE PROCESSES IN THE OUTER MAGNETOSPHERE

V.S.Danilova (Institute of Cosmophysical Research and Aeronomy, 31 Lenin Ave., 677891 Yakutsk, Russia)

The proton acceleration processes in shearing flows at the Earth's magnetosphere boundary and bow shock can be considered on the basis of a kinetic equation where the expansion of distribution function in angular moments is used. This model of particle scattering on plasma instabilities allows to obtain the transport coefficients (conductivity and viscosity) too. The acceleration processes of protons in the low-latitude boundary layer and in the mantle are considered. An analysis of Pc 3-4 pulsation activity at the choosed by us method of data treatment at the Yakutsk station ($\Phi' = 56°$, $\Lambda' = 199°$) allows to conclude that MHD-waves accompanying the population of the ions accelerated by the diffusive shock mechanism in quasiparallel regions of the bow shock are a source of these pulsations.

SOLAR CYCLE AND SEASON VARIATIONS OF THE STRONG MAGNETIC STORM PROBABILITY

A. Dmitriev, D. Kalinin and S. Kuznetsov (Skobeltsyn Institute of Nuclear Physics, Moscow State University, Vorobjevy Gory, Moscow, 119899,Russia)

The data base containing 489 strong magnetic storms (Dst≤-90) during the time period 1957-1995 is used to study the variations of the storm appearance probability. The relation between a number of the storms and the solar activity are discussed. The magnetic storm power spectra for time intervals of the minimum, increase, maximum and decline phases of solar activity are presented. The well correlation of year averaged number of strong magnetic storms and Wolf number is critically dropped in the case of month averaged storm numbers due to a season variation of storm appearance probability. The study of this phenomena shows a strong dependence of the storm number on the inclination of the Earth's dipole axis in the solar-ecliptic meridian plane. The change of magnetic storm power spectrum with changing of season is presented.

THE ANALYTIC MODELING OF THE HIGH-LATITUDE ELECTRIC FIELD CONTROLLED BY IMF

L.A. Dremukhina, Y.I. Feldstein, A.E.Levitin, V.O. Papitashvili (IZMIRAN, 142092 Troitsk, Moscow Region, Russia)

The model of the electric field and currents in the high latitudes (IZMEM) presents distributions of the electric potential, the electric field and the current systems only in concrete points: corrected latitudes $\Phi' = 60°.61°.....88°.89°.90°$ and MLT = 1.2....23.24. In this work we give IZMEM model presentation in analytic form f(Φ',MLT,By,Bz) and compare it with another modern models (Foster, Heppner and Maynard) and with experimental data from satellites and radars. The main goal of this work is to discuss types of convection paterns at the high latitudes in connection with IMF situations: $Bz > 0$ and $Bz < 0$ (three and four convection cells - it is reality or only speculation?). Besides we take into consideration the connection of the space distribution of convection patterns with different seasons which is absent in another modern models.

MODELLING OF ENERGETIC ELECTRONS PROPAGATION INTO MAGNETOSPHERE ACCORDING TO THE SATELLITE DATA.

Elisarov S.V. and Mineev Yu.V.
Scobeltsyn Institute of Nuclear Physics, Moscow State University,
119899 Vorobjevy Gory, Moscow, Russia

The energetic electrons (Ee=0.04-2.0 MeV) propagation from the boundaries of magnetosphere to ionospheric altitudes is considered. Radial diffusion is taking into account as the main cause of particles transfer. The value of the radial diffusion coefficients (Dom, Doe and Dll) are determined as result of solving the equations for electrons distribution function with dissipative term for quiet geomagnetic periods. The energetic electrons data from "Intercosmos-19" satellite were used. The regions of electric and magnetic diffusion mechanisms dominating obtained for different electrons energy. Energetic dependence of the radial diffusion coefficient Dll is investigated taking into account particles losses mechanisms for different L-shells (L=1.2-5.0). To calculate the radial diffusion coefficient the Coloumn losses and wave-particle interaction were considered for different electrons energy and L-shells. Experimental data for plasma density and waves intensity were used to calculate influence of these mechanisms. Analitic expressions were obtained for connections between particles', waves' and plasma's parameters with magnetic and electric fields into magnetosphere. A comparison of obtained values with ones obtained from another experiments, theoretical investigations and modelling is made. To calculate the radial diffusion coefficient and dissipative mechanisms contribution wave measurement data from satellites of "Intercosmos" series used.

OPTIMUM FREQUENCY VARIATION FOR THE EXTENDED SECOND-ORDER GYRORESONANCE INTERACTION OF WHISTLER WITH ELECTRONS

N. Erokhin and N.Zolnikova (Space Research Institute, Profsouznaya Str.84/32, 117810 Moscow, Russi a)
M.J. Rycroft (International Space University, Parc d'Innovation, Boulevard Genthier d'Andernach, F-67400 Illkirch, France)
D. Nunn (Department of Electronics and Computer Science, University of Southampt on, SO9 5NH Southampton, UK)

The nonlinear cyclotron resonance interaction of energetic electrons with ducted
finite amplitude whistler of variable frequency propagating through the transien t plasma layer in the magnetosphere is studied numerically. It is shown that there
are the optimum frequency variations, compensating both the geomagnetic and plas ma inhomogeneities influence, which allow an existence of extended second-order resonance interaction for group of synchronous electrons and the whistler-wave growth also. The possible application of results obtained to the magnetospheric conditions is discussed. This work is supported by INTAS (grant 94-2753).

GLOBAL ELECTRODYNAMICS OF THE IONOSPHERE-MAGNETOSPHERE SYSTEM

Y.I.Feldstein, L.I Gromova, S.A.Golyshev, A.E.Levitin (IZMIRAN, 142092 Trotsk, Moscow Region, Russia)
G.Marklund, L Blomberg, P.-A.Lindqvist, T.Karlsson (Alfven Laboratory, S-100 44 Stockholm, Sweden)

Global patterns of the magnetospheric convection predicted by the models of the different authors are compared for the concrete event on September 25, 1986. The IZMEM, Millstone Hill, Heppner et al., and Weimer models and the Marklund and Blomberg, AMIE methods are used for the convection patterns descriptions for instantaneous moment at 20.46 UT. The electrostatic potential variations, the electric field intensity values calculated by different models along the VIKING satellite pass are compared with the similar satellite observations data. It turns out that results of calculations for 20.46 UT moment for some models are rather well coincide with the satellite observations. The correlation increases if the magnetospheric electromagnetic state changes for the time interval of the satellite pass through the high-latitude region due to the Bz and By IMF variations are taken into account. The expected magnetic field vectors patterns on the ground were calculated. The modeled magnetic fields intensity values in the horizontal plane ΔT were compared with the data of the global magnetic high-latitude observatories network. The good agreement between some models and measured electric fields along the ionospheric footprint of the VIKING orbit may further serve as a justification of model calculations results.

MAGNETIC SIGNATURES OF MAGNETOSPHERIC SUBSTORMS SIMULTANEOUSLY OBSERVED BY SCATHA AND GEOS 2

P.H.M Galopeau (Centre d'Étude des Environnements Terrestre et Planétaires, 10-12 Av. de l'Europe, F-78140 Vélizy, France)
S. Perraut, A. Roux (CETP, 10-12 Av. de l'Europe, F-78140 Vélizy, France) and Ø. Holter (Department of Physics, University of Oslo, Norway)

We have examined the magnetic field data collected by the P78-2 satellite SCATHA, in order to identify the signatures of magnetic substorms. The time resolution of these data (0.25 sec) allows to perform a precise wavelet analysis. We have selected time sequences allowing to correlate the magnetic field data observed simultaneously by SCATHA and the geostationary satellite GEOS 2 when it is close enough to SCATHA. The purpose of our study is to distinguish spatial and temporal variations of the phenomena inferred by magnetospheric substorms. We also compare the magnetic observations to differential energy flux data of electrons (187 eV - 140 keV) and protons (154 eV - 133 keV).

MAGNETOSPHERIC FIELD LINE RESONANCES: SIENCE FICTION OR SCIENCE REALITY?

Karl-Heinz Glassmeier (Institut für Geophysik und Meteorologie, Technical University of Braunschweig

Magnetic field line resonances are the current paradigm for the understanding of ULF-pulsations in the Earth magnetosphere. First proposed by Tamao (1965) this resonant coupling between fast and intermediate modes became a standard reference in most ULF pulsation papers since Southwood (1974) and Chen and Hasegawa (1974) have been able to demonstrate that many characteristics of ULF pulsations can be explained by considering the field line resonance phenomenon. Major extensions of the theory were presented e.g. Tamao (1979) or Inhester (1987), who studied fieldline resonances in compressible plasma and considered kinetic Alfvén waves. Fieldline resonance became a more general topic of magnetospheric physics ever since Goertz et al. (1986) proposed resonant mode coupling as a driving mechanism of magnetospheric substorms and Samson et al. (1991) showed that fieldline resonances can be used to explain features of auroral arcs. More recently, however, Bellan (1994) argued that the resonant mode coupling is merely a spurious effect of an improper application of ideal MHD theory. Bellan's (1994) criticsm initiated an interesting scientific controversy (e.g. Ruderman et al., 1995; Wright and Allan, 1996). A critical review of the controversy will be presented.

A STATISTICAL STUDY OF DISPERSIONLESS SUBSTORM ION INJECTIONS OBSERVED BY CRRES

A. M. Hall (Leicester University and Rutherford Appleton Laboratory, UK)
C. H. Perry and M. Grande (Rutherford Appleton Laboratory, Didcot, UK)
M. Lester (Leicester University, Leicester, LE1 7RH, UK)
B. Wilken (Max-Planck-Institut für Aeronomie, Lindau, Germany)

We present an analysis of observations of dispersionless energetic ion injections during substorms made by the MICS instrument on CRRES. Masses up to iron can be measured by MICS in the energy range 10 to 430 keV/q. This dataset has been used to quantify ion composition during substorm injections. The CRRES orbit provides the opportunity to investigate injection signatures extending from magnetic latitudes of $\approx \pm 30$ degrees and L-Shells between 4 and 8. Corrections are applied for the uneven sampling of the magnetosphere inherent in the CRRES geostationary transfer orbit. In particular, spatial differences (MLT, MLat and L-Shell) between isolated and multiple ion injections, as well as the spatial differences for injections of different composition are investigated. Subsets are selected from a numerical database of *c.* 120 dispersionless events observed between December 1990 and July 1991 when spacecraft apogee was in the near-tail. We will discuss and present properties of the numerical database with emphasis on the quantification of substorm parameters including composition.

ION COMPOSITION CHANGES DURING MULTIPLE SUBSTORM INJECTIONS & THE PENETRATION OF SOLAR WIND IONS TO RING CURRENT ALTITUDES DURING STORMTIME

A. M. Hall (Leicester University and Rutherford Appleton Laboratory, UK)
C. H. Perry and M. Grande (Rutherford Appleton Laboratory, Didcot, UK)
M. Lester (Leicester University, Leicester, LE1 7RH, UK)
B. Wilken (Max-Planck-Institut für Aeronomie, Lindau, Germany)

Between 20:00 UT on 12 March 1991 and 02:00 UT on 13 March 1991 the MICS instrument onboard CRRES observed two multiple dispersionless ion injection events with significant differences in their morphology, composition and spatial location. The *Dst* index shows that the two sets of injections are observed at the beginning and end of the growth phase of a small and short lived magnetic storm. During this interval the spacecraft ground track was located in the European sector. We use supporting ground-based instrumentation in the five hours MLT extent that substorm effects were witnessed to place the single point spacecraft observations in the context of substorm current systems. We concentrate in particular on the composition changes observed as a function of L-Shell, MLat and *Dst* and the penetration of solar wind (high Z and q) material to ring current altitudes ($L \approx 5.5$).

HOW THE MAGNETOPAUSE TRANSITION PARAMETER WORKS

Mike Hapgood and Mike Lockwood (Rutherford Appleton Laboratory, Chilton, Didcot, Oxfordshire, UK OX11 0QX)

It has been known for nearly a decade that particle and magnetic field data in the low-latitude boundary layer (LLBL) are frequently (85% of cases) and remarkably well-ordered by a *transition parameter* derived from electron number density, N_e, and temperature, T_e. However the physical processes which underly the ordering have remained a mystery — thus limiting the application of the transition parameter to LLBL studies. We show here that the transition parameter ordering may be a consequence of magnetopause reconnection. We use a simple time-of-flight model to simulate the mixing of magnetosheath and magnetospheric plasma following reconnection. This model reproduces the observed anti-correlation of N_e and T_e from which the transition parameter is calculated and suggests that transition parameter is related to the time since a flux tube was reconnected. We suggest that the transition parameter ordering of LLBL data may indicate that this layer is, in most cases, formed as a result of plasma mixing via magnetopause reconnection.

Transequatorial motion and sedimentation of the CRRES G-9 barium ions

Harald U. Frey, G. Haerendel (Max-Planck-Institute for extraterrestrial physics, D-85740 Garching, Germany)

The CRRES G-9 barium release was designed for the investigation of field line tracing between the release point at 17.4 degrees north latitude and the area of ion cloud sedimentation at about -41 degrees south latitude. Optical observations of the barium ion cloud motion showed the appearance of a small filament separated from the main ion cloud while other striations characteristic for high altitude releases were absent. The arrival of the ions in the southern hemisphere confirmed an additional acceleration just after the ion cloud release. The field line tracing between the northern and the southern hemispheres further confirmed field line equipotentiality between both hemispheres during this experiment.

A SEARCH FOR GROUND MAGNETIC FIELD SIGNATURES OF FLUX TRANSFER EVENTS

N. V. Ivchenko (Kiev Shevchenko University, Physics Faculty, Kiev, Ukraine)
J. Blecki (Space Research Center, Polish Academy of Sciences, Warsaw, Poland)

Flux Transfer Events observed in the outer magnetosphere are considered by many authors to be flux tubes of open magnetic field lines crossing the magnetopause. If this model is accepted, the motion of open field region will lead to certain signatures in the ionosphere, which in principle could be used to distinguish between the versions of FTE models. A search for ionospheric effects of FTE has been conducted using Prognoz-8, AMPTE-UKS, ISEE-1, 2 satellite data and relevant ground magnetic observations. Use of high latitude data, such as Prognoz-8 provided widen the perpective on the Flux Transfer Events which are normally reported near equator. Besides that, Prognoz-8 and AMPTE-UKS operated during the periods of different solar activity, which implies different solar wind condition. Several types of possible ground effects are described. Their statistical properties and probable causes are discussed basing on the available data.

THE POSSIBLE EFFECTS OF THE IMF TURNINGS ON THE SLOUGH CRITICAL FREQUENCIES, foF2

A. Kaya, METU(ODTU) Dept. of Aeronautical Engineering, Ankara, Turkey
Y.Tulunay, METU(ODTU) Dept. of Aeronautical Engineering, Ankara, Turkey

The Interplanetary Magnetic Field turnings seem to be responsible for dynamical variations of the upper atmosphere. Therefore, a possible influence of the IMF on the ionospheric critical frequenciies may be plausible (Rishbeth, 1988). Starting with the idea of such a coupling,the possible effects of the IMF Bz polarity changes has been studied extensively by Tulunay (1995). These studies quantified that day-to-day variability of the mid-latitude ionospheric F region which could be related to changes in orientation of southward Bz. As a consequence of such findings it was stated that the possibility of dayside auroral heating in the northern hemisphere is greater for IMF By < 0 than for By > 0 (Tulunay, et.al., 1996). As a next step the IMF By polarities and solar sector boundary crossings were considered in this work. The results of the data analysis presented herewith indicated that the southward turning of IMF Bz and By > 0 polarities produced about an order of magnitude changes in the averaged dfoF2 values.

LONGPERIOD GEOMAGNETIC PULSATIONS NEAR CUSP AND TRANSPOLAR AURORAL ARC (TETA-AURORA)

N.G. Kleimenova, O.V. Kozyreva (Institute of the Earth Physics, Moscow 123810, Russia)
J. Bitterly (Institute of the Earth Physics, Strasbourg, France)

The analysis of digital ULF-data at polar Antarctic station Dumont d'Urville (=80,6) has been done during teta-aurora observed by DE-1 satellite above this station near local noon on May 11,1983. It was found, that the bursts of longperiod geomagnetic pulsations with spectral maximun in the frequency range 2-3 mHz accompanied the teta-aurora appearance. The pulsations were registered in D- and Z-components. There was no signal in the H-component. The negative magnetic bay only in D-component was simultaneously observed. The sourse of pulsations is probably connected with formation of the NBZ-system of field aligned currents wich usually developed near the transpolar arc edges. It has been shown also that as a rule the teta-aurora arising take place when Bz IMF is strong positive (10-15 nT), solar wind density and velocity are high.

EQUILIBRIUM CONDITIONS FOR THE TD MAGNETOPAUSE: IMPLICATIONS FOR ITS THICKNESS AND THE SENSE OF MAGNETIC FIELD ROTATION

J. De Keyser and M. Roth (Belgian Institute for Space Aeronomy, Ringlaan 3, B-1180 Brussels, Belgium)

The present study analyzes the influence of the magnetosheath magnetic field and magnetosheath flow on the equilibrium configuration of a tangential discontinuity magnetopause. We have found (a) necessary and sufficient conditions for the existence of a TD equilibrium, (b) a thickness estimate that agrees well with satellite data and that accounts for the observed dependency on magnetic latitude and magnetic field rotation angle, (c) a preference for clockwise magnetic field rotation in the northern and counterclockwise rotation in the southern hemisphere at the high magnetic shear dayside magnetopause, and the converse at the tail flanks, and (d) indications that TD equilibrium may be lost more easily at the low magnetic shear dawn magnetopause than at the dusk side.

ON THE POSSIBLE EXISTENCE OF RESONATORS FOR ALFVEN WAVES IN THE AXIALLY-SYMMETRIC MAGNETOSPHERE WITH FINITE PLASMA PRESSURE

Dm. Yu. Klimushkin (Institute of Solar-Terrestrial Physics, Irkutsk 33, P.O.Box 4026, 664033, Russia)

This paper addresses the question of the spatial structure of radially-polarized geomagnetic pulsations with large values of the azimuthal wave number $m \gg 1$ in the magnetosphere. It is shown that resonators for Alfven waves can occur in regions where the dependence of magnetospheric parameters (Alfven velocity, the ratio of plasma to magnetic pressure, and equilibrium current) on the coordinate across magnetic shells has an extremum, i.e. in the plasmapause and partial ring-current regions. In these resonators, the mode is confined between the magnetic shells called the poloidal shells due to the fact that oscillations of field lines on these surfaces are purely poloidally polarized. Inside the resonator, the mode is a standing one not only along the geomagnetic field but also across magnetic surfaces. Outside this region, the wave dies out exponentially. Such a structure of the mode arises from the transverse dispersion of the Alfven wave caused by the combined action of the curvature of field lines and finite plasma pressure. It is hypothesized that some types of geomagnetic pulsations (such as poloidally-polarized Pc4 pulsations) are the resonator's eigen oscillations in the partial ring-current region.

DETAILED EXAMINATION OF THE STORM/SUBSTORM RELATIONSHIP USING ENERGETIC PARTICLE MEASUREMENTS FROM THE WHOLE CRRES MISSION

A Korth, R. H. W. Friedel and C. Mouikis (Max-Planck-Institute for Aeronomie, 37189 Lindau, Germany)

There has been much recent controversy on the exact role of the substorm/storm relationship in the filling and maintaining of the inner radiation belts. We use here data from the whole of the CRRES mission to show the large variety of storm/substorm dynamics, leading to different behaviour of the main ring-current indicator, the D_{ST} index. Substorms can occur quite independently of main storms and do not always lead to a filling of the radiation belts: We have data here that shows an actual decrease of the ring current population during a period of substorm activity, even though D_{ST} shows a moderate decrease. We can show here that the exact nature of storm/substorm interrelationship is highly dynamic and depends on the previous state of the magnetosphere.

Spatial displacements of enhanced proton flux regions during the substorm observed by CRRES

T.V.Kozelova, L.L.Lazutin, B.V.Kozelov (Polar Geophysical Institute, Apatity, Russia)
R.Rasinkangas (University of Oulu, Finland)
A.Korth (Max-Planck-Institut fur Aeronomie, Katlenburg-Lindau, Germany)
H.Singer (Space Environment Laboratory, NOAA, Boulder, USA)

Energetic particle and magnetic field data from spacecraft CRRES are used to examine the spatial evolution of particle activation region during two substorms. The analysis of azimuthal anisotropy of proton fluxes showed that: (1) particle acceleration region associated with subsequent proton flux enhancements is displaced tailward from the distance ~ 6.3 Re; (2) the flux enhancement for protons with guiding centers located Earthward from spacecraft and tailward stretching of magnetic field lines are the earliest signatures of substorm expansion onset. This dynamic behavior of particles and magnetic field may be consistent with such causes of substorm expansion onset as current disruption and ballooning instability.

EMPIRICAL MODEL OF THE DAYSIDE MAGNETOPAUSE

S. Kuznetsov and A. Suvorova (Skobeltsyn Institute of Nuclear Physics, Moscow State University, Vorobjevy Gory, Moscow, 119899,Russia)

Dayside magnetopause model is presented alternative to well-known Roelof and Sibeck model. Model parameters are the same: solar wind dynamic pressure and Bz-component of the interplanetary magnetic field. The main differences and features of the model are the larger statistics and wider effective range of model parameter and the different method of the data treatment. The first is due to geosynchronous satellite magnetopause crossings added to the basic data on high-apogee crossing. The second is based on physical approach to the analysis of the data. There were found from geosynchronous data analysis an asymmetric dayside magnetopause shape during disturbed solar wind condition and the pressure balance change manner during strong negative Bz.

CHARGE REDISTRIBUTION IN CELL MEMBRANES AS A POSSIBLE MECHANISM OF GEOMAGNETIC FIELD PATHOGENIC ACTION

Vassily A. Loginov (Chair of Aerospace and Environmental Medicine, Space Biomedical Center for Training and Research, Lomonosovsky av., Build. 5, Moscow, Russia)
Vladimir Ya. Klimovitsky (Institute of Biomedical Problems, Moscow, Russia)

Analysis of available data on biological effects of changed geomagnetic field (GF, 24-68 uT) enables one to make three major conclusions: a) long-time experiments with hypogeomagnetic conditions revealed a functional abnormalities in high organisms;b) theory predicting a possibility of biological significant electric forces induction in living tissue during the high speed movement in GF (airplane, space vehicle - 22 nT/s); c) cell, organism and population reactions are perversed during fluctuations of GF (100 nT) under influence of solar activity. The real molecular mechanism of pathogenic GF action is still unknown. We propose a membrane charge distribution conception (MC/DC) as an explanation to these results. The main of MC/DC is: localized and delocalized surface membrane charges (SMC) plays a crucial role in cellular reactions to changed GF. The redistribution of SMC in cells induced by GF can alter normal lipid-protein interaction. It results in functional cell disorders determined by lipid-protein complexes quit near the cellular and subcellular membranes. Such membrane mediated cellular functions as ionic permeability, enzymatic activity and receptor-ligand interaction may by a possible pathogenic elements of manifesting the organism to changed GF. Also MC/DC predicts alterations in tissue excitability and contractility.

RAY TRACING STUDIES OF NARROW-BANDED ELF EMISSIONS

O.A.Maltseva (Institute of Physics Stachky Str 194, Rostov-on-Don 344090 Russia)
E.E.Titova(Polar Geophysical Institute, Fersman Str 14, Apatity 184200 Russia)

In order to use observations of ELF waves at low-altitude satellites as a diagnostic tool it is necessary to answer some questions: i) what kind of auroral plasma structures is an observation of waves connected with, ii) how is the source of waves localized relative to these structures? The numerical simulation of ELF propagation by the ray tracing method gives the following answers: i) the observation of ELF waves requires an existence of irregularities like blobs, ii)the structure of these blobs must be three-dimentional,their electron density enhancement can not be less than 4, the half-width dL of blobs cannot exceed 0.1-0.2, ii) the source of emissions is located not in centre but on the border or even outside blobs. Results of modeling are confirmed by observations.

WAVE DUCTING IN DIFFERENT FREQUENCY BANDS AS A TOOL OF STUDY OF MAGNETOSPHERIC PLASMA

O.A.Maltseva (Institute of Physics,Stachky Str 194, Rostov-on-Don,344090 Russia)

Wave ducting has great diagnostic possibilities in different frequency bands from parts of Hz up to hundreds MHz because it allows to determine parameters of ducting irregularities from large-scale structures(like magnetopause,plasmapause detecting by MHD,ELF,VLF waves) to small-scale ones(like ducts,bubbles detecting by VLF, MF, HF, UHF waves). The aim of this paper is to find a general criterion of ducting on basis of numerical simulation of the angle PSI behaviour along ray traces (PSI is the wave normal angle to the magnetic field of the Earth). It is shown that analytical criterion,connecting parameters of channels with the frequency of waves and characteristic plasma frequencies, can be developed in the definite points(dPSI/ds=0) of ray traces.This criterion determines also conditions of traping, keeping and leaking waves.

ENERGETIC QUASI-TRAPPED ELECTRON FLUXES NEAR THE INNER BOUNDARY OF INNER RADIATION BELT.

I. N. Myagkova, S. N. Kuznetsov, Yu. I. Denisov and Yu. V. Gotselyuk (Skobeltsyn Institute of Nuclear Physics, Moscow State University, Vorobjovy Gory, 119899 Moscow, Russia)

Fluxes of 0.5-1.3 MeV electrons at altitude about 500 km were investigated in the experiment on-board 'CORONAS-I' satellite launched in March 1994. The detector with large geometric factor ($60sr * cm^2$) was used for the measurements at L=1.1-1.5. In the west side of Brazilian Magnetic Anomaly the significant electron fluxes were detected in comparing with the east side. This quasi-trapped electron region size was founded. The values of angles of electron scattering for one bounce time interval and time life of electrons due to their scattering were estimated.

Plasma Spectral Changes Across A Potential Drop: Theory, Simulation and Application to Polar Rain Data

P. T. Newell, S. Wing and C.-I. Meng (Johns Hopkins Applied Physics Laboratory, Laurel, MD 20723)

A basic problem in magnetospheric physics is the change in plasma characteristics from a variation in electric potential. We investigated this problem theoretically, empirically, and with simulations. Three distinct well-defined types of solutions are found. The first of these (the "textbook" or "standard" solution) is that a Maxwellian with temperature kT and density n after passing through a potential change becomes a Maxwellian with the same temperature but a density $n\exp(-q*POT/kT)$. This solution appears clearly in the simulations in the limiting case where a small region with a potential is in equilibrium with a vastly larger reservoir of plasma outside the potential region. If, however, a finite cloud of plasma passes entirely through a potential drop, the above solution is not possible, since it conserves neither energy nor particle number. Instead a different set of well-defined solutions appears in the simulations, derivable theoretically from conservation laws. These "finite-cloud" solutions have markedly non-Maxwellian characteristics, with either an enhancement or a shortage of low-energy particles depending on the presence of pitch-angle scattering across the potential ramp. In addition to showing excellent agreement between simulations and the finite-cloud solutions, we compared polar rain observations to these 3 theoretical forms. The polar rain data proved to be generally better fit by the finite-cloud injection formulas than by the standard "equilibrium with an infinite reservoir" formula.

UBIQUITY OF ALFVEN RESONANCES IN SPACE PLASMA

V.A. Pilipenko (Institute of the Earth Physics, Moscow 123810, Russia)

Ideas on resonant transformation of compressional modes into Alfven waves are widely used in laboratory and space plasma. Basic notions of AR theory are commonly formulated within the framework of a model with a "plasma box" limited by the conductive ionospheres. This report presents a number of observational effects: a) variations of ULF wave spectral structure at low latitudes, b) near-equatorial localization of ULF activity in the terrestrial and Jovian magnetospheres, c) selective amplification of MHD noises in the cusp region, d) distortions of ULF spatial structure upon the transmission through the ionosphere. The interpretation of these effects is suggested, which requires theoretical consideration beyond common AR theory.

THE SOLAR WIND CONTROL OF ELECTRON FLUXES ON THE GEOSTATIONARY ORBIT

G.V.Popov, V.I.Degtjarev, S.S.Sheshukov (Institute of Solar-Terrestrial Physics,P.O.Box 4026,664033 Irkutsk,Russia)
A.D.Johnstone (MSSL,University London,Dorking,Surrey RH5 6NT,England)
Geoff Reeves (LANL,NIS-2,Mail Stop D-436, Los Alamos, New Mexico, 87545, USA)

The relation between between electron fluxes variations registered on geostationary orbit and solar wind velocity, Dst, solar activity was investigated. Three-hours averaged LANL-data for energy range 30-1360 keV were daily smoothed and correlated with solar and geophysical data. Time period from July 1978 till December 1978 was analised. Both 27-day and seasonal variations of electron fluxes demonstrate significant correlation with solar wind velocity and solar activity index. The time lag between solar wind variations and 27-day electron fluxes variations increases with the electron energy. This fact is interpreted as a manifestation of diffusion of electrons, primarily accelerated outside of the geostationary orbit and drifting to it. The seasonal variations of electrons with different energies demonstrate different response to the solar activity variations. Some interpretation of these features taking into account differences in solar wind streams is proposed.

POLYTROPIC INDEX AND PROTON PITCH-ANGLE DIFFUSION IN THE MAGNETOSHEATH

M.I. Pudovkin[1], C.-V. Meister[2], B.P. Besser[3], S.A. Zaitseva[1]
[1]Institute of Physics, St. Petersburg State University, 198904, Russia,
[2]Space Plasma Physics, Potsdam University, 14469, Germany,
[3]Space Research Institute, Academy of Sciences, 8010 Graz, Austria

The effective polytropic index γ in a magnetized anisotropic plasma is obtained within the frame of double-adiabatic magnetohydrodynamics. The value of γ is found to depend on the characteristics of the plasma flow, and on the temperature anisotropy. The energy transfer between the perpendicular ($T_\perp$) and parallel ($T_\parallel$) (with respect to the magnetic field) proton temperatures is shown to change significantly not only the temperature profiles across the magnetosheath but also the values of the adiabatic indices. The proton temperature anisotropy relaxation time τ in the magnetosheath is estimated, and it is shown that the value of τ obtained from $T_\parallel$ is systematically larger than the value obtained from the $T_\perp$ variation. This means that the rate of the perpendicular energy decrease is greater than the parallel energy increase, which suggests the existence of perpendicular energy sinks. For short duration processes, such as e.g. the slow shock crossing, when the energy transfer between $T_\parallel$ and $T_\perp$ may be neglected, the polytropic index γ equals 2–3 near the bow shock, and it is $\gamma<1$ in the magnetopause vicinity.

PROPAGATION OF THE SUBSTORM INJECTION REGION MEASURED BY LANL AND CRRES

G. D. Reeves, M. G. Henderson, P. S. Mclachlan and R. D. Belian (Los Alamos National Lab., Los Alamos NM, 87545, USA)
R. H. W. Friedel and A. Korth (Max-Planck-Institute for Aeronomie, 37189 Lindau, Germany)

The relationship between substorm injections and other substorm phenomena has taken on increasing importance in recent years as we have developed a better understanding of the role that the near-Earth magnetosphere plays in the overall substorm process. To investigate this relationship we surveyed the entire CRRES database for dispersionless substorm injections. We then surveyed the Los Alamos database for times when one or more geosynchronous spacecraft also observed a dispersionless substorm injection. We found 29 cases where an unambiguous onset could be identified in both data sets. We analyzed the time delay between the geosynchronous and CRRES injections as a function of both local time and radius. While no clear propagation in local time could be identified we found that in all 29 cases the time delay was consistent with an inward propagation from geosynchronous orbit to lower L-shells. In the 9 events for which the two spacecraft were separated by less than one hour of local time the time delay was a linear function of radial separation suggesting an effective propagation speed of only 24 km/s. This slow propagation speed and the close association of injection times with substorm onset times implies that the source region for the injected particles is close to L=6.6 Re.

DYNAMICS OF TAIL-LIKE CURRENT LAYER STRUCTURE WITH LOCAL PLASMA TURBULENCE

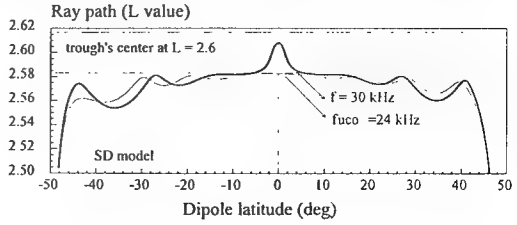
A. V. Runov and **M. I. Pudovkin** (Institute of Physics, St. Petersburg State University, St. Petersburg, Russia 198904)
C.-V. Meister (Institute for Theoretical Physics and Astrophysics, Potsdam University, 14469, Germany)

Results of the simulation of the current layer evolution caused by anomalous resistivity development are presented. Initial configuration is given as the tail-like equilibrium layer with nonzero normal component of the magnetic field. It is supposed that the anomalous resistivity in the layer is the consequence of the local plasma turbulence. In such case the anomalous resistivity is proportional to the effective collision frequency ν^*, which is determined by the type of plasma turbulence. We use for ν^* model dependencies on the velocity of current carrying particles $\nu^* \sim j/\rho$ and on squared gradient of magnetic pressure $\nu^* \sim (\nabla B^2)^2$. Obtained results include the temporal and spatial evolution of the magnetic and electric fields, plasma convection topology, density, pressure and temperature variations.

MAIN FEATURES OF THE UPPER CUT-OFF FREQUENCY FOR WHISTLERS GUIDED BY A TROUGH

D. M. Šulić Geomagnetic Institute 11306 Grocka, Belgrade, Yugoslavia
D. P. Grubor Geomagnetic Institute 11306 Grocka, Belgrade, Yugoslavia

For realistic model of the electron density and field model whistlers guided by a trough have $f_{uco} \sim 0.5\ f_{Bmin}$ and $f_n \sim 0.37\ f_{Bmin}$. In frequency range less then f_{uco} whistlers are guided by or around the trough's inner side and ray can not penetrate the trough's center. Here we present results of guiding very narrow frequency range larger than f_{uco} (~ 20%) by a trough. The main feature of this guiding is that in the equatorial range ray penetrates deep in trough and crosses the trough's center. Initial latitude ranges for these frequencies are very narrow. Ray paths for f_{uco} = 24 kHz and f = 30 kHz versus dipole latitude are presented in Figure.



TRANSIENT AURORAL EVENTS IN THE DAYSIDE SECTOR DURING STRONGLY NORTHWARD IMF

V.R.Tagirov, Ismagilov V.S. (Polar Geophysical Institute, Apatity, Russia)
V.A.Arinin (Russian Federal Nuclear Center, Sarov, 607200, Russia)
D.Sibeck (Applied Physics Laboratory, John Hopkins University, Laurel, USA)

The interaction of magnetic cloud with the Earth's magnetosphere on the basis of TV auroral observations, magnetic ground-based and IMF data and plasma parameters of the solar wind was studied for the time interval from 04.17 to 10.30 UT on 14 01.1988. Auroral TV observations were carried out in Frants-Joseph Land (Heiss Island) and covered the whole dayside sector corresponding to the event. Auroral forms represented very active rayed forms traveling mostly in azimuth direction with velocities about several kilometers per second. The polar plots of auroral motion showed that they moved following to "inverse" twin-cell convection pattern with sunward flow over the pole. We divided the whole interval of auroral observations into three regimes depending on the characteristics of auroral motion and solar wind and IMF parameters. The IMF Bz-component during the whole interval was very high exceeding 18 nT whereas By-component changed the sign at about 1.5 h later the local magnetic noon at the point of auroral observations, By was slightly positive. The first regime was characterized by a very steep increase in solar wind dynamic pressure. The second regime differed by much less dynamic pressure values and pronounced sunward flow motion of auroral forms. The third regime was characterized by change of auroral forms velocity vector to the eastward direction. The possible mechanisms of transient events generation for all three regimes are discussed.

TOWARDS MODEL OF EXCITATION OF GEOMAGNETIC PULSATIONS BY ENERGETIC PARTICLES

O. P. Verkhoglyadova (Dept. of Astronomy and Space Physics, Kiev University, Vladimirskaya 64, Kiev 252033, Ukraine)

Kinetic theory of geomagnetic pulsations in a realistic magnetosphere plasma model was developed in paper [1] on the basis of the low-frequency gyrokinetic equations. This theory studies the excitation of plasma waves in the low-frequency wave range with taking into account plasma nonuniformity, pressure anisotropy, field line curvature, magnetic trapping and wave-particle interaction. The reduced eigenmode equations were obtained in [1] and analyzed.
In the current paper the another way of analysis is considered which is based on the principles of the variational calculus. Stability and physical properties of the waves are studied for several cases.
1. Chen L., Hasegawa A.//J. Geophys.Res. 1991. 96, A2. P.1503.

WHISTLER DUCTS AND FIELD LINE SHELLS - ARE THEY IDENTICAL?

J Verő, L Holló, P Bencze and F Märcz (Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences, Sopron)

Data from the processing of about 1700 whistlers recorded at Tihany (L value of propagation, equatorial electron density and tube content) are compared to pulsation characteristics (mainly of periods) as recorded at the nearby Nagycenk Observatory (both at L ~ 2). It is found that pulsation periods are the longer if whistlers propagate at the higher L values. In addition, the total number of whistlers in hourly collected samples as recorded at Panska Ves (Czech Republic) for more than ten years (1971-79, 1987, 1990) is compared to the Nagycenk pulsation activity. Again, pulsation activity increases in the presence of whistler activity, and the connection (with daytime Pc3 activity) holds for both night- and day-time whistlers. Both results can be reconciled with the supposition that whistler ducts and field line shells are in close connection with each other as they appear simultaneously with enhanced probability and the position of these structures is similar within the magnetosphere, too. Whistler ducts lying adjacent to each other may constitute shells of field lines playing a role in the excitation of Pc3 pulssations.

NEURAL NETWORK PREDICTION OF SMOOTHED AE DATA

J. Takalo, and J. Timonen (Department of Physics, University of Jyväskylä, P.O.Box 35, FIN-40351, Jyväskylä, Finland)

Neural network (NN) models were costructed to study prediction of AE index. In this analysis gradient descent multilayer backpropagation neural networks were used. Both solar wind (vB_s) and previous AE inputs were used to predict AE data for different amounts of time steps ahead. It seems that that prediction of the original unsmoothed AE data is possible only for 10 time steps (25 min) ahead. The predicted time series of the AE data for 50 time steps (125 min) ahead was found to be even dynamically different from the original time series. It seems that the NN model cannot reproduce the turbulent part of the power spectrum of the AE data. However, when using smoothed AE data the prediction for 10 time steps ahead gave NMSE 0.0623 and correlation coefficient 0.97. The generalisation ability of the model gradually decreased when the number of time steps increased, but is quite good up to predictions of 30 time steps (75 min) ahead. Predicting beyond 40 time steps (100 min) ahead does not anymore give reasonable predictions. This is also consistent with the fact that the characteristic time scale (autocorrelation time) of the AE data is of the order of 2 hours.

UPSTREAM WAVES AND FIELD LINE RESONANCES: SIMULTANEOUS PRESENCE AND ALTERNATION IN Pc3 PULSATION EVENTS

J. Verő, Cz. Miletits, L. Holló, J. Szendrői and B. Zieger, (Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences, H-9401 Sopron, Pf. 5, Hungary)
H. Lühr (GeoForschungsZentrum Potsdam, Champ Project Office, D-14473 Potsdam, Telegrafenberg, Germany)
M. Vellante (Dipartimento di Fisica, Universita dell'Aquila, I-67010 Coppito-L'Aquila, Italy)
I. Best (GeoForschungsZentrum Potsdam, Adolf Schmidt Geomagnetisches Observatorium, D-14823 Niemegk, Germany)
J. Střeštik (Geofyzikální Ústav, AV ČR, Praha 4, Spořilov. Bočni II 1401, CZ-14131, Czech Republic)

A detailed study of Pc3 events at an array between L=1.5 to 3 detected quick changes between upstream waves (UW) and field line resonance (FLR, azimuthal oscillations of geomagnetic field lines). The alternation of the two types is more characteristic and the UW part is the stronger if the interplanetary magnetic field is highly variable. Events due to FLR have a structure consisting of multiple lines of frequencies differing by about 10 percent, corresponding to neighbouring shells of field lines. A similar change in the FLR frequency (about 10 percent at a distance of 80 km at the surface) was found by Waters et al, too. Other signals of unidentified origin also seem to be influenced by IMF.

KINETIC ALFVEN WAVES IN MAGNETOSPHERE: NONLINEAR INTERACTION AND TURBULENT SPECTRA

Yu.M.Voitenko (Main Astronomical Observatory, Kyiv, 252650, Ukraine)

The nonlinear kinetic theory of kinetic Alfven waves (KAWs) turbulence in the Earth magnetosphere is developed. The power-law Kolmogorov-type spectra for long-wave KAW turbulence (with wave-number spectrum index = -5) and short-wave KAW turbulence (with wave-number spectrum index = -3) are found. The level and wave-number spectrum of long-wave KAW turbulence are in good agreement with in situ observations of the low-frequency turbulence in magnetosphere regions where intense field-aligned currents are also observed. This supply a strong evidence for nonlinear spreading of long-wave KAW spectra, generated by the current-driven KAW instability. Due to the Doppler shifts, the wave-number spectrum appeares in the satellite reference as frequency spectrum with index -4.

THE SPATIAL SCALES OF THE MAGNETIC FIELD INCREASE IN THE RAMP REGIONS OF SUPERCRITICAL QUASI-PERPENDICULAR BOW SHOCKS

S. N. Walker, M.A. Balikhin, H.St.C. Alleyne and L.J.C Woolliscroft (Space Instrumentation Group, Department of Automatic Control and System s Engineering, University of Sheffield)
W.A.C. Mier-Jedrzejowicz (Department of Physics, Imperial College of Science, Technology and Medi cine)
W. Baumjohann (Max Planck Institut für Aeronomie, Garching bei Munchen)

This paper presents the results a statistical study of the spatial scales of the ramp region of supercritical, quasi-perpendicular shocks using AMPTE-UKS and AM PTE-IRM magnetic field measurements, during crossings of the Earths bow shock. T he results show that L_{exp} is much less than the ion inertial length c/ω_{pi}.
The determination of the spatial scale can provide information regarding the mec hanism which prevents the shock from steepening. Comparison between the observed ramp scale and theoretical ramp scales for supercritical quasi-perpendicular sh ocks show that anomalous resistivity may be ruled out as the appropriate mechanism whilst the r amp scale is consistent with a mechanism based upon nonlinear dynamics.

GEOACTIVITY IN RESPONSE TO CIR/CME EVENTS - A SYNOPTIC VIEW

B. Wilken, Q -G. Zong (Max-Planck-Institut für Aeronomie, Germany)
D.N.Baker (LAPP, University of Colorado, USA)
T. Doke (Waseda University, Japan)
N. Hasebe (Faculty of General Education, Ehime University, Japan)
T. Mukai,T. Yamamoto (ISAS, Japan)
G. Reeves (Los Alamos National Laboratory, USA)
S. Ullaland (University of Bergen, Norway)

Interplanetary corrotating interaction regions (CIRs) and isolated coronal mass ejections (CMEs) between December 1993 and June 1994 created intervals with enhanced activity in the magnetosphere, each about 10 days in duration. A total of seven such quasi-periodic intervals was monitored by GEOTAIL from different vantage points in geospace. The HEP-LD spectrometer measured the mass composition and velocity distribution of energetic ion populations resulting from these sustained magnetospheric activities inside the magnetosphere (near Earth and distant tail) and outside the magnetopause (magnetosheath and interplanetary space). Intense proton and helium fluxes with spectral distributions extending to rather high energies (up to 2 MeV or higher) are a magnetospheric product of these disturbances. Short bursts of oxygen ions emanating most likely from reconnection regions were detected on interplanetary field lines. The GEOTAIL observations elsewhere in geospace are complemented by corresponding measurements in the 'vicinity' of Earth (fleet of geostationary satellites and SAMPEX in a low altitude polar orbit).

SELF-CONSISTENT KINETIC SIMULATIONS OF IONS DYNAMICS IN A RECONFIGURATING MAGNETOSPHERE

E. B. Wodnicka (Space Research Centre, Polish Academy of Sciences, Bartycka 18a, 00716 Warsaw, Poland)

In the study ion energization processes are simulated. Self-consistent electromagnetic particle codes are used. Electric field induced by the time-dependent magnetic field is taken into account as an external field.The evolution of electric and magnetic fields resulting from charge and current distribution is demonstrated for different initial conditions. Ions full dynamics is combined with two electron models; massless fluid model or guiding center approximation for perpendicular and parallel motion. The evolution of velocity distribution function for protons and oxygen ions is presented. The pressure anisotropy of plasma components is evaluated for the two models of plasma.

INTERPRETATION OF ULF SPATIAL-SPECTRAL STRUCTURE: SUCCESS AND INADEQUACY OF FLR THEORY

N. Yagova (Institute of the Earth Physics, Moscow 123810, Russia)
K. Yumoto (Kuyshu University, Fukuoka 812, Japan)

New possibilities of diagnostics of magnetosphere and solar wind with the ground-based ULF waves are suggested. Spectral content of Pc3-4 and Pi2 geomagnetic pulsations measured at 210 MM network is analyzed. Events observed demonstrate different types of latitude-frequency distributions. The special analysis makes it possible to separate simultaneous influences on the spectra of a of driving source and of local field line resonant (FLR) effects. The numerical model of the magnetosphere-ionosphere Alfven resonator has been elaborated. The model is based on realistic plasma distributions and allows to estimate the role of a FLR effects in the ULF structure under different geophysical conditions. The empirical model of electron density distribution based on whistler measurements has been revised and extrapolated to lower latitudes, using the data of ULF observations. However, a class of day side ULF events exists with no evident resonant effects, which properties seem to contradict the FLR theory. The possible constraints and inadequacy of the standard FLR theory are discussed.

MAPPING OF THE IONOSPHERIC TRAVELLING CONVECTION VORTICES TO THE MAGNETOSPHERE

A.G.Yahnin (Polar Geophysical Institute, Apatity, 184200, Russia)
T.Moretto (Danish Meteorological Institute, Copenhagen, Denmark)

13 events of the TCVs were selected from the list of the TCV observations made in 1990-91 by the Greenland magnetometer array. The criterion for selection was the coincidence of TCV observation with the overpass of the low-altitude NOAA satellite measuring the energetic (>30 keV) precipitating particles. Additionally, the low-energy particle data from the closest DMSP satellite crossings were considered. From the NOAA satellite data we found the TCVs to be located 1) at the outer edge of the energetic electron precipitation, and 2) well equatorward of the energetic proton isotropy boundary. The latest means that magnetic field in the magnetosphere equatorial plane is more than some tens of nT. The DMSP measurements of <30 keV particles show that TCVs are equatorward from the boundary between the Central Plasma Sheet and Boundary Plasma Sheet precipitation domains. Thus, our analysis provides the clear evidence that TSVs do not map to the Low Latitude Boundary Layer, as it was suggested earlier, but to the inner plasma sheet. We discuss a possible TCV mechanism as a result of generation and propagation of a surface wave inside the plasma sheet.

THE PLASMA SHEET POSITION AS FUNCTION OF Bz AND By INTERPLANETARY MAGNETIC FIELD COMPONENTS: THE INTERBALL/TAIL PROBE OBSERVATIONS

Yu.I.Yermolaev, V.I.Prokhorenko, L.M.Zelenyi (Space Research Institute, Russian Academy of Sciences, Profsoyuznaya 84/32, 117810 Moscow, Russia)
J.Buechner (Max-Planck-Institute for Extraterrestrial Physics, Rudower Chaussee 5, D-12489 Berlin-Adlershof, Germany)

One of the important aim of INTERBALL project is study of structure and dynamics of geomagnetic tail including plasma sheet and neutral sheet. In accordance with orbit evolution at period from the middle of September, 1995 to the end of February, 1996 the satellite passes the plasma sheet at regular interval of about 4 days in geomagnetic time regions of 6-0 and then 24-18 LT and at geocentric distances from 3 to 28 Earth' radii. On the basis of plasma and magnetic field observations the positions of plasma sheet and its dependence on the interplanetary magnetic field By and Bz componets are studied and compared with previous results and models. Average magnetic field components in the plasma sheet for different orientation of IMF are studied as well. IMF Bz and By components result in asymmetry of the plasma sheet in Z and Y direction, respectively.

PLASMOIDS BOUNDARY STRUCTURE: GEOTAIL OBSERVATIONS

Q.-G. Zong (Max-Planck-Institut für Aeronomie, D-37191 Katlenburg-Lindau, Germany)
B. Wilken (Max-Planck-Institut für Aeronomie, D-37191 Katlenburg-Lindau, Germany)
G. Reeves (Los Alamos National Laboratory, USA)
T. Doke (Waseda University, Japan)
T. Mukai,T. Yamamoto (ISAS, Japan)
S. Kokubun (STEL, Nagoya University, Japan)
S. Ullaland (University of Bergen, Norway)

The discussion of plasmoids presented in this paper refers to established and well documented plasmoid events observed with the GEOTAIL satellite. The plasmoids were encountered in the distant tail.
The plasmoid boundary data are ordered in a boundary normal coordinate system, which is determined by the use of the Principal Axis Analysis (PAA) method. In this system, the magnetic field components parallel to the plasmoid boundary exhibit a rotational character, i.e. the field rotates through nearly 180^0; the magnetic field components perpendicular to the boundary are continuous, the magnitude of this component often assumes rather small values. Plasmoid with significant normal component in its boundary appear to be associated with strong oxygen bursts whereas oxygen bursts seem to be absent in events with small or zero normal field components. Finally, the structure and width of the plasmoid boundary layers are discussed.

ST5 Open session on solar and heliospheric physics (incl. Soho)

Convener: Marsden, R.G.
Co-Convener: Foing, B.H.

LONG-PERIOD MODULATION OF GALACTIC COSMIC RAYS AND FEATURES THE SOLAR WIND'S LARGE-SCALE STRUCTURE

M.V. Alania [1,2], T.B. Bochorishvili[1], and K. Iskra[1]

1 *Institute of Mathematics and Physics of Siedlce University, Siedlce, Poland*
2 *Institute of Geophysics of Academy of Sciences of Georgia, Tbilisi, Georgia*

The temporal changes of the energy spectrum index γ of the Long-period variations of galactic cosmic rays based on the date of neutron monitors and meson telescopes for the period of 1970-1994 have been investigated. It is shown that the energy spectrum index γ depends on the energy , especially, in the maximum epochs of solar activity. Besides, there was found that the spatial changes the galactic cosmic rays' parallel diffusion coefficient $\mathbf{K}_{||}$ is proportional on the energy **R** as follows, $\mathbf{K}_{||} \propto \mathbf{R}^{\gamma}$; in addition, γ itself depends on the energy **R** and on the coordinates r, ϑ, φ. $(\gamma = \gamma\,(\mathbf{R},r,\vartheta,\varphi))$. The latter is causing by the spatial changes of the large-scale structure of the solar wind versus both the solar activity and spatial coordinates. Taking into account the above-mentioned dependence for the diffusion coefficient $\mathbf{K}_{||}$, the drift included transport equation of galactic cosmic rays for **2-D** case **(r,ϑ)** has been solved.

SIGN-SINGULAR MEASURES OF THE CURRENT HELICITY IN SOLAR ACTIVE REGIONS ON THE BASIS OF VECTOR MAGNETOGRAMS

V. I. Abramenko and V. B. Yurchishin (Crimean Astrophysical Observatory, 334413, Nauchny, Crimea, Ukraine)
V. Carbone (Dipartimento di Fisica, Universita' della Calabria, 87036 Rende (CS), Italy)

Signed measures of stochastic fields show a sign-singular behavior related to extreme and violent oscillations in sign. On the basis of vector magnetic field measurements in active regions, we calculate the current helicity h_c in the photosphere and we show that, for all 22 active regions we examined, the signed measure is sign-singular. Our results allow us to address the problem of (dc) magnetic field energy build up in the solar atmosphere which may contribute to explosive events and to the general heating of corona. In fact, it has been shown that the necessary condition for the alfa-effect is the presence of a predominant sign of current helicity over a given volume. Sign-singularity represents a signature of a scaling phenomenon underlying the dominance of a sign of the current helicity at a certain scale, thus experimentally confirming the presence of necessary condition for alfa-effect. With our method, we are able to address also the scaling laws of turbulence in the transverse magnetic field of the photosphere. Our method represents a new way of investigating vector magnetograms in the photosphere by looking at new statistical concepts. In this sense it can be applied to active regions where the determination of quantities through the visual inspection of H-alfa patterns is not reliable.

ON THE ROLE OF THE MEDIUM SCALE TURBULENCE IN THE FORMATION OF STABLE STRUCTURES IN THE SOLAR ATMOSPHERE

E. E. Antonova and **I. L. Ovchinnikov** (Scobeltsyn Institute of Nuclear Physics, Moscow State University, Moscow, 119899, Russia)

The theory in which the turbulent diffusion provides the structure stability is suggested. The medium-scale developed plasma turbulence can support the stability of one-dimensional plasma sheet formed by the large scale plasma flow. The developed turbulence creates quasi-diffusive flux of particles against the pressure gradient. This flux can compensate the compressing action of the large-scale motion and as a result form the stable plasma sheet. The characteristic feature of this sheet is homogeneous electron and ion temperature across the sheet due to plasma mixing. The suggested dependence of the regular velocity and quasi-diffusion coefficient on the magnetic field determine the plasma pressure dependence on the magnetic field and gives the possibility to solve Grad–Shafranov equation and to restore the magnetic configuration. The theory is generalized for the two-dimensional case.
The comparison of the modeling results with data of observations have shown that the suggested model may help to understand the processes of solar prominences formation. On the first stage hot plasma sheet in corona is formed. The large-scale plasma motion decreasing leads to the plasma sheet expansion due to turbulence action and field-aligned upward directed plasma pressure drop is formed. It causes the siphon mechanism action and plasma sheet filling by cold chromospheric plasma.

MODEL OF THE MAGNETIC FIELD NEAR THE SUN

M. Banaszkiewicz (Space Research Centre, Bartycka 18A, Pl-00716, Warsaw, Poland)
J.F. McKenzie and W.I. Axford (Max-Planck-Institut für Aeronomie, D-37189 Katlenburg-Lindau, Germany)

A new model of the circumsolar magnetic field is postulated. In addition to the Sun dipolar field and the current-sheet monopolar term considered earlier, a quadrupole component is introduced. The relative strength of these three fields is determined from: (i) the magnetic field value at 1 AU, (ii) the condition that the last open field line has its footprint at 60 deg latitude in the base of the corona, and (iii) the morphology of plasma flows near the base as observed by the SUMER and LASCO experiments on the SOHO mission. A sequence of models with increasing strenght of the quadrupole term will be presented and discussed with emphasis on the magnetic field topology close to the equatorial plane where singularities (neutral points) might appear for a large intensity quadrupole field. In our best-fit model the qudrupole term near the Sun dominates the dipole component, contributing to about 60% of the total field in the polar regions of the base.

THE DYNAMICS OF DUST PARTICLES IN THE VICINITY OF THE SUN: I. THE EFFECTS OF THE SLOW SOLAR WIND

M. Banaszkiewicz (Space Research Center, Bartycka 18a, Pl00716 Warsaw, Poland)
H.J. Fahr (Institut für Astrophysik und Extraterrestrische Forschung der Universität Bonn, Auf dem Hügel 71, D-53121 Bonn, Germany)
I. Mann and K. Scherer (Max-Planck-Institut für Aeronomie, P.O. Box 20, D-37189 Katlenburg-Lindau, Germany)

Close to the Sun the orbits of dust particles undergo orbital perturbations different from those further out. This is connected with the acceleration of the ecliptic solar wind wind to higher Mach numbers, as well as by the strong octupol moments of the solar magnetic fields. In Banaszkiewicz et al. (1994) it was shown that the Plasma Poynting-Robertson force rapidly increases for decreasing Mach number, and hence the PR-lifetime of the dust particle shortens. Therefore, realistic solar wind models will be incorporated into our present orbital pertubation program. We will present first results and check for a possible influence on the size distribution and the mass budget of dust particles near the Sun.

EISCAT measurements of co-rotating interaction regions

A.R. Breen, P.J. Moran, C.A. Varley, W.P. Wilkinson and P.J.S. Williams, University of Wales, Aberystwyth
W.A. Coles, University of California, San Diego
J. Markkanen, EISCAT, Sodankyla

Co-rotating interaction regions (CIRs) between regions of fast and slow solar wind are a prominent feature of the solar wind. Measurements of interplanetary scintillation using the three widely, seperated antennas of the EISCAT facility have been been able to detect the compression regions at the leading edge of CIRs and to determine the location and velocity of the structure. Observaations have indicated CIRs at distances as close to the Sun as 27 solar radii, a result supported by theoretical modelling which shows that the conditions needed for CIRs to develop can exist closer to the Sun than 30 solar radii. EISCAT is ideally suited to studying the development of CIRs at radial distances between 27 and 130 solar radii: observations from 1993-1996 are discussed in this paper.

INCREASING OF THE SOLAR WIND MAGNETIC FIELD NEAR THE MAGNETOPAUSES OF QUICKLY SPINNING PLANETS

E.S. Belenkaya (Institute of Nuclear Physics, Moscow State University, 119899 Moscow, Russia)

A mechanism of a solar wind magnetic field amplification in the thin transition layer just outside the magnetopause of a quickly spinning planet is proposed. When the ionosphere and magnetopause conductivities of the rapidly rotating planet are sufficiently high, but less than the field-aligned conductivity, the circulation exists at the magnetopause in the open field line bundles. The toroidal magnetic field is generated there from the poloidal ambient magnetosheath magnetic field by differential rotation. The requirement of the alpha-effect existence is satisfied due to the deviation from axial symmetry about the planet's rotation axis of the initial magnetosheath velocity and magnetic fields. This provides regeneration of poloidal magnetic field from the increasing toroidal one.

RESULTS ON NEON PICKUP IONS FROM MEASUREMENTS WITH SOHO/CELIAS/CTOF AND COMPARISON WITH MODEL CALCULATIONS

A. T. Bogdanov, B. Klecker and D. Hovestadt (Max-Planck-Institut für extraterrestrische Physik, Giessenbachstraße, 85740 Garching, Germany)
H. Grünwaldt and M. Hilchenbach (Max-Planck-Institut für Aeronomie, Katlenburg-Lindau, Germany)
F. M. Ipavich (Department of Physics and Astronomy and IPST, University of Maryland, College Park, MD 20742, USA)
F. Gliem (Institut für Datenverarbeitung, Technische Universität Braunschweig, Braunschweig, Germany)
P. Bochsler (Physikalisches Institut der Universität Bern, Schweiz)
E. Möbius (EOS, University of New Hampshire, Durham, NH 03824 USA)
and the SOHO/CELIAS TEAM ()

We report on newly obtained results on neon pickup ions from the SOHO/CELIAS/CTOF Instrument - a time-of-flight mass spectrometer which measures the charge composition of ions from solar wind energies up to 35 keV/e. As a result of its large geometrical factor and the continuous observation mode, for the first time singly charged Ne ions originating from the neutral interstellar gas component could be measured as near as one astronomical unit to the sun. These measurements are used in combination with model calculations of the pickup ion distributions to refine our understanding of the properties of the interstellar source of these particles and the processes leading to their ionization and coupling to the solar wind.

Comet Hyakutake (C 1996 B2): Latitudinal Variations and the Major Disconnection Event Seen on March 25, 1996

John C. Brandt, Yu Yi, Martin Snow, and Carolyn Collins Petersen Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO 80309-0392 USA

Comet Hyakutake with its orbital inclination of 124.9=A1 and naked eye brightness during parts of March & April 1996 provided an opportunity to test the picture of a two-part solar wind: (1) a polar region with high speeds, low densities, and relative absence of variations in all properties versus (2) an equatorial region with low speeds, high densities, and relatively large variations including the heliospheric current sheet (HCS). Images of comet Hyakutake obtained by the Ulysses Comet Watch are analyzed for plasma tail orientation as an indicator of solar-wind speed, and examined for the latitude of disconnection events (DEs) and variations in general appearance. Comparison is made with results for comet de Vico (122P).
The spectacular DE seen on March 25, 1996 is clearly related to a magnetic reversal in the solar wind seen by IMP-8 and WIND. This DE occurred when the comet was approximately 12=A1 from the calculated HCS and may be an example of a DE produced by a local magnetic reversal not associated with the global HCS.

ULYSSES COMPOSITION, PLASMA AND MAGNETIC FIELD OBSERVATIONS OF HIGH SPEED SOLAR WIND STREAMS

M.E. Burton, Jet Propulsion Laboratory, E.J. Smith (JPL), M. Neugebauer (JPL), D.J. McComas (Los Alamos), R. von Steiger (University of Bern), G. Gloeckler (University of Maryland)

During 1992-3 as the Ulysses spacecraft passed in and out of the southern high speed solar wind stream, the Solar Wind Ion Spectrometer, SWICS made continuous composition and temperature measurements of all major solar wind ions. A close anti-correlation between both the O^{7+}/O^{6+} freezing-in temperature and the Mg/O ratio with the solar wind velocity was found [Geiss et al., 1995]. The transition between low and high speed streams was found to be very steep for both parameters at both the leading and trailing edge of the stream. These observations suggest that the chromosphere and corona have a common, relatively sharp boundary separating the low- from the high-FIP (first ionization potential) region in the chromosphere and the low- from the high-temperature region in the corona and further imply that chromospheric processes must be included in discussions of the origin of the solar wind. Siscoe et al. [1995] found the specific entropy of the ions, which is proportional to $\ln(T_i/n^{\gamma-1})$, and which should be a constant of the flow, to be enhanced in high-speed stream and further an abrupt increase to be a good indicator of the stream interface. Goldstein et al., [1996] found $T/n^{1/2}$ to be better predicted by solar wind speed than temperature alone. In this study, a comparison of the specific entropy with both the O^{7+}/O^{6+} freezing-in temperature and the ratio Mg/O has been made. A close anti correlation is found including a discontinuous change in entropy exactly coincidence with both the leading and the trailing edge of the high-speed stream identified in the SWICS data. These observations suggest a new useful combination of solar wind parameters which can serve as an identifier of high speed solar wind flow in the absence of data of the type the SWICS instrument provides.

MINOR ION AND MULTIPLE CRITICAL POINTS IN SOLAR WIND ACCELERATION

A. Czechowski and R. Ratkiewicz (Space Research Centre, Bartycka 18A, PL-00-716 Warsaw, Poland)
J. F. McKenzie and W. I. Axford (Max-Planck-Institut für Aeronomie, Postfach 20, D-37189 Katlenburg-Lindau, Germany)

We use a steady-state model of a three component plasma flow to study the acceleration of the (fast) multi-ion solar wind originating in a coronal hole. The Alfven wave force is given by the complete expression (without low speed approximation). As the dominant heat source we take the wave energy dissipation close to the solar surface, leading to preferential heating of the heavy (minor) species. The critical solution, which represents the flow passing from fully subsonic to fully supersonic speeds is obtained by a method based on the critical (generalized sonic point) structure of the phase space of the system. The calculations are performed for a set of different model assumptions. In particular, we examine the effects of different detailed heating mechanisms by varying the component temperature or entropy profiles. The results are consistent with UVCS/SOHO observations of high particle speeds for heavy ions close to the Sun.

MAGNETIC FIELD LINE "RE-CONNECTION": INCORRECT TERMIN OR INCORRECT CONCEPT?

Alexandr D. CHERTKOV (Institute of Physics, St. Petersburg University, St. Petersburg, Petrodvorets, 198904, Russia)

Disruption, disconnection, or "re-connection" of line of force for magnetic field B are directly prohibited by the law div B = 0, that is the absence of magnetic charges. Thus, the termin is at least inaccurate one. But the whole concept starting from the image of an individualized line of force is incorrect. The magnetic field B in space is a consequence of electrical currents, which determine this vector field. The currents are the causes for B. Redistribution of currents causes changes in vector field B. Re-connections of electric currents are allowed by MHD set. An attempt to obtain currents knowing magnetic field redistribution is in general case an incorrectly formulated inverse problem. It is demonstrated, that so called "solutions of Petschek's problem" do not satisfy MHD set and boundary conditions.

SOLAR CYCLE VARIATIONS OF LOCAL VELOCITY AND TEMPERATURE OF THE INTERPLANETARY HYDROGEN

Maciej Bzowski and Daniel Ruciński (Space Research Centre of the Polish Academy of Sciences, Bartycka 18 A, 00-716 Warsaw, Poland)
Hans J. Fahr and Horst Scherer (Institut für Astrophysik und Extraterrestrische Forschung der Universität Bonn, Auf dem Hügel 71, D53121, Bonn, Germany)

Using a time-dependent kinetic approach the density, bulk velocity vector, and temperature tensor of interstellar hydrogen in the inner Solar System in several phases of a typical solar cycle were computed. Due to the action of solar ionisation and radiation pressure the bulk velocity of the gas is strongly variable during solar cycle and within 15–30 AU from the Sun it significantly changes with the heliocentric distance. Typical changes are about 15 km/s and exceed the thermal spread of the gas. The anisotropy of local temperature is strong and variable in time and fades off with the heliocentric distance. The projections of temperature on various lines can change from 5 000 to 11 000 K upwind and from ~12 000 to 45 000 K downwind at 1 AU. The change of radial temperature along a line of sight is strongest during solar minimum and equal to about 3 000 K upwind and about 5 000 K downwind. The upwind-to-downwind backscattered Lyman-α intensity ratio varies by about 20% around the mean value. For observations from 1 AU the Doppler shift of interplanetary lines reflects the bulk speed "in infinity" for the lines of sight directed downwind whereas for the lines of sight directed upwind the Doppler shift is usually increased by about 25%. The width of interplanetary upwind lines reflects the gas temperature "in infinity" while the line width of crosswind and downwind returns temperatures higher by ~3 000 K with no simple seasonal correlation.

FORMULATIONS OF PROBLEMS IN PLASMA KINETICS FOR SOLAR WIND AND INTERNAL SUN

Alexandr D. CHERTKOV (Institute of Physics, St. Petersburg University, St. Petersburg, Petrodvorets, 198904, Russia)

Current moment in physics of the solar wind and internal Sun is characterized by great difficulties, connected with impossibility to describe the observed properties of fully ionized space plasma in framework of a unified selfconsistent theory. It stems from the fundamental error in the usual way of theoretical calculations, replacing the parallel interaction of plasma particles by the series of consequent collisions with very rapid lost of information about previous state of plasma. The history of plasma physics had two bifurcation points: one in 1937 and the other in 1946. Both were connected with the preference of simplified calculation methods over deep analysis of plasma properties. Then the theory confronted with the results of controlled fusion experiments, and till now it is not adequate to experimental and empirical data. Formulations of problems in plasma kinetics for the fully ionized plasma in the solar wind and internal regions of the Sun are investigated from the point of view of modern thermodinamics for open systems. The initial and boundary conditions are set up in the explicit form for the finite volums. An introducing of a special fundamental oscillating distribution function for plasma is proved. This function is determined by the process of plasma creation and depended on the real sources of energy, which have very low entropy. For the solar wind it is an induction electric field of solar origin, for the internal Sun it is a flux of energetic particles from thermonuclear reactions. The changes in descripting parameters of plasma in MHD approximation are discussed. It is shown, that the suggested approach can give the way to constracting the selfconsistent models of the solar wind and the Sun.

ULYSSES OBSERVATIONS OF RECURRENT ENERGETIC ION (~1 MEV) INTENSITY INCREASES IN THE THREE-DIMENSIONAL HELIOSPHERE

M. I. Desai, R. G. Marsden, T. R. Sanderson, (Space Science Department, ESTEC/ESA, Postbus 299, 2200 AG Noordwijk, The Netherlands)
A. Balogh, R. J. Forsyth, (Blackett Laboratory, Imperial College, London, UK.)

During the traversal of the southern hemisphere, the COSPIN/Low Energy Telescope (LET) onboard the Ulysses spacecraft detected increases in the energetic ion (~1 MeV) intensity associated with (i) corotating compression regions (period ~26 days) that are commonly known as CIRs, and (ii) occasional transient events. Following the fast latitude scan (from February 1995 to April 1995), this activity evolved into a relatively quiet period from the perspective of energetic particles. This period of low activity lasted until October 1995 during which Ulysses slowly descended from the northern polar regions toward the ecliptic plane. Since late October 1995, when Ulysses was at a heliographic latitude of ~66°N, the LET has observed a somewhat more complex pattern (compared with that observed in the southern hemisphere) of recurrent enhancements in the energetic ion intensity. We highlight the key latitudinal, radial, and hemispheric differences in our observations and discuss the new results in view of changes in solar activity and in the location of the spacecraft.

COROTATION PARTICLE ENHANCEMENTS: CORONAS-I AND ULYSSES DATA COMPARISON ANALYSIS.

A. Dmitriev and S. Kuznetsov (Skobeltsyn Institute of Nuclear Physics, Moscow State University, Vorobjevy Gory, Moscow, 119899,Russia)

The results of comparison analysis of corotation particle enhancements detected by near Earth polar orbit satellite CORONAS-I in the ecliptic plane and by Ulysses on the high helio-latitudes are presented. The most significant 1-4.5 MeV proton enhancement observed by CORONAS-I satellite are related with the Earth crossing the corotation shock of boundary between slow and fast solar wind streams (from solar equator region and from south coronal hole respectively). The independence of time delay between Ulysses particle enhancement observations and CORONAS-I observations on the change of Ulysses heliolongitude location (from E5 to E79 during March-June, 1994) is found. This independence can be defined by remarkable increase of Ulysses heliolatitudes (from S56 to S67 respectively). In this case we sagest the IMF lines connected with Ulysses at high latitude drop at medium latitudes with increase of distance from the Sun and cross the corotating interaction region (CIR) region at latitude <S30 at the distance >5AU. The presence of CORONAS-I observations of corotating particle enhancement associated with corotation shock connected with fast solar wind stream from North coronal hole and absence of respective fluxes detected by Ulysses on high latitudes shows that the high latitude IMF line can not be dropped at the near ecliptic heliolatitudes.

ACR-INDUCED ELECTRIC FIELDS NEAR THE TERMINATION SHOCK

Hans J.Fahr and Horst Fichtner, Institute for Astrophysics of the University of Bonn, Auf dem Hügel 71, D-53121 Bonn (Germany)

Much is known about the relevant processes in the outer heliosphere, but only few things are well known. The solar wind should for sure run into an outer heliospheric termination shock, but it is widely open what precisely happens at this shock. Is it a strong shock, is it a weak one, does it have a precursor, possibly leading into a smooth transition from supersonic to subsonic solar wind signatures? Closely related to these open questions are phase space features and abundances of pick-up ions and anomalous cosmic ray ions, the former generally being considered as the generator of the latter. What has only poorly been studied up to now is the fate of electrons in the region close to the shock. Their role, however, in forming a consistent shock scenario must be very important as we are going to show. We calculate the space charge electric fields associated with anomalous cosmic ray protons diffusing upstream from the shock. The resulting electric fields would drastically decelerate the solar wind, and would cause strong drift electric currents in the precursor region. A consistent picture can only be hoped for if anomalous cosmic ray electrons are considered as interfering with the scenario.

NON-EQUILIBRIUM MOMENT TRANSFER BETWEEN THE CONSTITUENTS OF A MULTI-SPECIES SOLAR WIND: HEATING AND COOLING IN THE INNER CORONA

H. Fichtner (Institut für Astrophysik und Extraterrestrische Forschung der Univerität Bonn, Auf dem Hügel 71, D-53121 Bonn, Germany)
N. Vormbrock (BASF-AG, ZX/ZC-C 13, D-67056 Ludwigshafen, Germany)
S.R. Sreenivasan (Department of Physics and Astronomy, University of Calgary, 2500 University Drive N.W., Calgary Alberta, T2N 1N4)

It has been suggested that the distribution functions characterizing the constituents of the solar coronal plasma are non-Maxwellian. If so, an accurate treatment of the collisional momentum and energy exchange between the plasma constituents within the framework of hydrodynamic models requires a re-evaluation of the general transfer integrals in multi-component plasmas. We have evaluated these integrals for both Maxwellian and non-Maxwellian distribution functions of the plasma species avoiding the standard approximation for the collision cross sections frequently employed in the literature. We demonstrate that, for the same plasma parameters, there exist not only significant magnitude differences in the collisional momentum and energy exchange rates for the different distributions, but that the moment transfer, compared to the Maxwellian case, can even be reversed in a non-equilibrium situation. Possible implications for the heating and cooling of the coronal plasma are discussed.

Irradiance Variation and Helioseismology from VIRGO/SOHO

C.Frochlich and the VIRGO Team
Physikalisch-Meteorologisches Observatorium Davos, World Radiation Center, CH-7260 Davos Dorf, Switzerland

The observations from the VIRGO experiment (Variability of solar IRradiance and Gravity Oscillations) on the ESA/NASA Mission SOHO (Solar and Heliospheric Observatory) started mid-January 1996 for the radiometers and sunphotometers (SPM) and near the end of March for the luminosity oscillation imager (LOI). The performance of all the instruments is very good, and the time series of the first year are evaluated in terms of solar irradiance variability, solar background noise characteristics and p mode oscillations. The solar irradiance is modulated by the passage of active regions across the disk, but not all of the modulation is straightforwardly explained in terms of sunspot flux blocking and facular enhancement. VIRGO provides for the first time simultaneous observations of total and spectral irradiance. This, together with the observations of LOI with its spatial resolution improves the diagnostics of solar irradiance variability substantially. As a result the understanding of the influence of bright magnetic features, such as faculae und network, has to be revised. The helioseismic results show evidence that magnetic activity plays a significant role in the dynamics of the oscillations beyond its modulation of the resonant frequencies. Moreover, by comparing the amplitudes of different components of p-mode multiplets, each of which are influenced differently by spatial inhomogeneity, we have found that activity influences the excitation.

THE EUV EMISSION IN POLAR HOLES FROM EIT IMAGES

J.-R. GABRYL, Observatoire Royal de Belgique
F. CLETTE, Observatoire Royal de Belgique
P. CUGNON, Observatoire Royal de Belgique

As the Sun has reached its minimum of activity, large coronal holes dominate in polar regions where the main part of the emitted radiation is due to polar plumes. The relative contribution of the background corona is still known with poor accuracy. However, in order to determine the physical conditions and the particles velocities in the polar holes. an accurate knowledge of the background corona is necessary. We propose a method to deduce this background corona from EIT observations. As an image results from the integration along the lines of sight, the polar signal is masked by lower latitude contributions. In order to extract the proper polar radiation, we assume that the EUV corona is optically thin and that the polar holes are stable and slowly changing with time. By averaging images through one solar rotation, the polar emission is enhanced with respect to the lower latitude contribution which is just spatially smoothed. We then modelize this average with a radial emissivity profile deduced from equatorial regions which we use to remove all non-polar signal in polar holes. We present here the results we obtained for the three EIT coronal wavelenghts (17.1, 19.5 and 28.4 nm).

CHARACTERISTICS AND ROTATIONAL SPLITTING OF INDIVIDUAL MODES FROM GOLF AND GONG EXPERIMENTS

Gavryuseva E., Gavryusev V.,GOLF & GONG groups

Institute for Nuclear Research, Pr.60th Oct. Ann.,7a, Moscow, 117312 Russia & OAC, Italy

The last data sets from GOLF and GONG experiments have been used for study of the line profiles and rotational splitting of global solar oscillations of low spherical degrees l = 0,1,2,3. Fourier Component Averaging technique has been applied, and line shape of each individual mode has been revealed directly without any fit. The frequency, the amplitude, the half-linewidth and the rotational splitting of each mode of radial numbers from n = 10 till n = 25 including components of different spherical orders oscillations will be presented for GOLF and GONG observations. The best statistical estimation of the rotational splittings and other characteristics has been performed based on the several data series provided by GONG group for the search of different spherical degree oscillations. The results are compared with IPHIR and IRIS measurements.

TEMPORAL BEHAVIOR OF GLOBAL OSCILLATIONS IN GONG EXPERIMENT

Gavryuseva E., Gavryusev V., GONG group

Institute for Nuclear Research, Pr.60th Oct. Ann.,7a, Moscow, 117312 Russia & OAC, Italy

Temporal behavior of low-order global p-modes has been studied based on the continuous data sets provided by GONG observations since May 1995. This period coincides with the change of the solar magnetic structure. The variations of p-mode power are sensitive to the state of solar activity and the responses of radial, dipole and quadrupole modes are different. The regular behavior is well visible at the beginning of the measurements during five solar rotations, especially for radial modes. Later on it passed through two big pulses and then transformed into the small stochastic perturbations when the solar activity is down. It would be very important for the understanding of the p-mode excitation mechanism to continue the study of the temporal behavior during the phase of solar activity rising.

THE VARIATIONS OF P-MODE POWER IN GOLF EXPERIMENT

Gavryuseva E., Gavryusev V., GOLF group

Institute for Nuclear Research, Pr.60th Oct. Ann.,7a, Moscow, 117312 Russia & OAC, Italy

The new GOLF data taken since April, 1996 have been used for the study of the temporal change of individual and global p-mode power during the period of low solar activity . The ratio of signal to noise is very high in this experiment, and p-mode power changes in 200 times. This clearly proves that such variations are real and cannot be simply explained by the in fluence of noise. We have to consider this effect as a representation of the dynamic of the mechanism of solar oscillations excitation and dumping. Quasi 13-day periodicity is visible in dipole mode power behavior. The radial oscillations are changing slower. The comparison with magnetic field and solar activity in dexes was performed and discussed in the paper.

ACCELERATION OF THE SOLAR WIND BY ALFVÉN WAVES

R. Grappin (Observatoire de Paris-Meudon, DAEC, 92195 Meudon, France)
A. Mangeney (Observatoire de Paris-Meudon, DESPA, 92195 Meudon, France)

We revisit the problem of the (nonlinear) acceleration of the solar wind by Alfv én waves produced at the base of the solar corona. We use a 2D axisymmetric MHD code with open boundary conditions; the waves are forced at the inner boundary of the atmosphere. The flow which is obtained for sufficiently long times is a supersonic flow consistent with the presence of Alfvén waves. We compare the results with usual Parker-type solutions and previous work both on acoustic (Grappin et al 1996) and Alfvén waves (Lau and Siregar, 1995).

BIRTH OF TURBULENT STREAMS IN THE ACCELERATING REGION OF THE SOLAR WIND

R. Grappin (Observatoire de Paris-Meudon, DAEC, 92195 Meudon, France)
A. Léorat (Observatoire de Paris-Meudon, DAEC, 92195 Meudon, France)
M. Velli (Dipartimento di Astronomia a Scienze dello Spazio, Largo Fermi 5, 50125 Italy)

The solar wind turbulence observed in situ close to the the ecliptic plane shows a spectrum well-developed on several decades of frequencies. The classical explanation (Coleman, 1968) invokes the free energy available in the stream structure, which feeds a turbulent cascade during the advection by the supersonic flow. Recent work by (Grappin and Velli, 1996) have shown that this process is inhibited by the expansion of the plasma, and that turbulence is probably frozen in at the stream scale at least. However, the onset of turbulence could well arise in the slowly expanding wind, below the sonic surface.
To cope with this problem, we simulated the time-dependent wind in an open configuration, with axisymmetry. We first studied the role of thermal fluctuations in the corona (Grappin et al, AandA, 1996, to appear); we consider here the magnetic effects, and discuss the relative importance of thermal and magnetic effects in the onset of stream interface instability. We find that turbulence may indeed arise close to the solar corona.

THE CONTRIBUTION OF COSMIC DUST PARTICLES TO LOW CHARGED SOLAR WIND COMPONENTS

H. Grünwaldt, I. Mann, and M. Hilchenbach (Max-Planck-Institut für Aeronomie, Postfach 20, D-37189 Katlenburg-Lindau, Germany)
P. Bochsler (Physical Institute, University of Berne, Sidlerstr. 5, CH-3012 Berne, Switzerland)
F. Ipavich (Department of Astronomy, University of Maryland, College Park, Maryland 20742-2421, U.S.A.)
and the CELIAS Team

Cosmic dust in interplanetary space provides an additional source of pick-up ions in the solar wind. These dust particles cover a size range below about 100 micron. They are produced by comets and asteroids and some particles enter the solar system from interstellar space. They produce ions when they sublimate close to the Sun, or when they are evaporated due to high velocity impacts, respectively collision. The measurements of the CTOF experiment on board SOHO yield a set of data describing the energy, charge and mass of ions in the solar wind. In the case of the elements C, N, O, we have detected and separated a component of low charged ions. We will compare these data to the elemental abundance and the mass balance of cosmic dust particles in the solar system.

CROSSING THE TAIL OF VENUS WITH CELIAS-CTOF ON SOHO

H. Grünwaldt (Max-Planck-Institut für Aeronomie, D-37189 Katlenburg-Lindau, Germany)
M. Neugebauer (Jet Propulsion Laboratory, Pasadena, CA 91103, USA)
P. Bochsler (University of Bern, Sidlerstr. 5, CH-3012 Bern, CH-3012 Bern, Switzerland)
D. Hovestadt (Max-Planck-Institut für extraterrestrische Physik, D 85740 Garching, Germany)
M. Hilchenbach (Max-Planck-Institut für Aeronomie, D-37189 Katlenburg-Lindau, Germany)
F.M.Ipavich (University of Maryland, College Park, MD 20742 MD, USA)
F. Gliem (Tech. University Braunschweig, D-38106 Braunschweig, Germany)

Much alike the coma of an active comet, the ionosphere of non-magnetic planets contributes appreciable numbers of charged particles to the solar wind. Such ions with various energy spectra have been found previously at close distance downstream of Venus and Mars. On the occasion of the June,1996 inferior conjunction with Venus, cool Tail Ray O+ and C+ were detected at the SOHO position by the CELIAS-CTOF solar wind mass spectrometer. Flux densities measured of the order of the nominal solar wind oxygen exhibit at large distance the in-situ observation of a celestial bodyś tail.

CELIAS-CTOF ON SOHO AS A FAST REMOTE CORONAL THERMOMETER

H. Grünwaldt (Max-Planck-Institut für Aeronomie, D-37189 Katlenburg-Lindau, Germany)
P. Bochsler (University of Bern, Sidlerstr. 5, CH-3012 Bern, CH-3012 Bern, Switzerland)
D. Hovestadt (Max-Planck-Institut für extraterrestrische Physik, D 85740 Garching, Germany)
M. Hilchenbach (Max-Planck-Institut für Aeronomie, D-37189 Katlenburg-Lindau, Germany)
F.M.Ipavich (University of Maryland, College Park, MD 20742 MD, USA)
F. Gliem (Tech. University Braunschweig, D-38106 Braunschweig, Germany)

The temperature of coronal electrons is classically derived from the ratio of optical line amplitudes that describe the temperature dependent charge distribution of suitable ion species. The availability of solar wind in-situ mass spectrometry has extended this method towards higher coronal altitudes and towards the determination of temperature gradients. With the high sensitivity of the ion charge spectrometer CELIAS-CTOF on SOHO the method could be used to study temperature variabiliy down to the length of an instrument cycle of 5 minutes: this improvement by about an order of magnitude demonstrated with Fe ion charge spectra adds fast temperature profiles to the diagnostics of coronal fine structure.

OBSERVATION OF ENERGETIC NEUTRAL HYDROGEN ATOMS WITH SOHO/CELIAS

M. Hilchenbach and H. Grünwaldt (Max-Planck-Institut für Aeronomie, D-37189 Katlenburg-Lindau, Germany)
K.C. Hsieh (University of Arizona, Tuscon, AZ 85721 USA)
F.M.Ipavich (University of Maryland,College Park, MD 20742 MD, USA)
F. Gliem (Tech. University Braunschweig, Braunschweig Germany)
P. Bochsler (University of Bern, Sidlerstr. 5, CH-3012 Bern, CH-3012 Bern, Switzerland)
D. Hovestadt (Max-Planck-Institut für extraterrestrische Physik, D 85740 Garching, Germany)

The time-of-flight mass spectrometer HSTOF of the CELIAS experiment on SOHO has the capability of detecting energetic neutral hydrogen atoms (ENHAs) between 50 and 80keV. We shall report on the ENHA flux limits derived from the data collect ed since launch and discuss the implications of this observation on the existing models of energetic neutral atom (ENA) production in the heliosphere, i.e. outer
heliosphere, co-rotating interaction regions and/or coronal or solar mass ejecti ons.

MEASUREMENTS OF SOLAR WIND VELOCITIES CLOSE TO THE SUN USING ULYSSES RADIO SOUNDING DATA

P. Janardhan and M. K. Bird (Radioastronomisches Institut, Universität Bonn, 53121 Bonn, Germany)
P. Edenhofer, D. Plettemeier and R. Wohlmuth (Institut für HF-Technik, Universität Bochum, 44780 Bochum, Germany)
S. W. Asmar (NASA-JPL, California Inst. of Tech., Pasadena, CA 91109, USA)
M. Pätzold and J. Karl (Inst. für Geophysik, U. Köln, 50923 Köln, Germany)

The *Ulysses* Solar Corona Experiment (SCE) was performed to obtain dual-frequency ranging and Doppler sounding measurements of the solar corona at distances from 4–40 $R_\odot$. The observations were conducted globally on a nearly continuous basis at the NASA Deep Space Network and other ground stations during the spacecraft's two solar conjuctions in summer 1991 and winter 1995. There were numerous occasions when observations were recorded simultaneously by two or more ground stations. These data have been used to estimate the solar wind velocity by cross-correlating the Doppler scintillations across separate coronal ray paths. The time lags obtained from the two-station cross correlations can be combined with those derived from uplink/downlink cross correlations to determine both the velocity and the location of the density fluctuations along the radio ray path. The strength of the correlation was found to be rather variable, sometimes diminishing to the point where a correlation time lag could not be reliably determined. A description of the correlation techniques, a hypothesis for the variability of the correlation strength, and a summary of the results are presented.

HELIUM CHARGE COMPOSITION IN CIRS AS OBSERVED WITH SOHO/CELIAS AT 1 AU

M. Hilchenbach and H. Grünwaldt (Max-Planck-Institut für Aeronomie, D-37189 Katlenburg-Lindau, Germany)
R. Kallenbach and P. Bochsler (University of Bern, Sidlerstr. 5, CH-3012 Bern, CH-3012 Bern, Switzerland)
H. Kucharek and D. Hovestadt (Max-Planck-Institut für extraterrestrische Physik, D 85740 Garching, Germany)
F. Gliem (Tech. University Braunschweig, Braunschweig Germany)
F.M.Ipavich (University of Maryland,College Park, MD 20742 MD, USA)

The time-of-flight mass spectrometer STOF (and HSTOF) of the CELIAS sensor on SO HO has the capability of detecting energetic ions between 35 and 700 keV/q (or up t o 1 MeV/nuc in HSTOF) and determines the mass, energy and charge (charge upper lim it in HSTOF) of each particle. We shall report on the flux ratio of He+ and He 2+ derived from the data collected since launch and discuss the implications of thi s observation on the existing models of particle acceleration in co-rotating interaction regions (CIRs), i.e. the seed particle population for the accelerati on process of corotating particle events.

CORONAL LOOP EMERGENCE AND EVOLUTION IN 3D*

G. Van Hoven and Y. Mok (University of California, Irvine, CA 92697, USA), and Z. Mikic (SAIC)

Current-carrying magnetic loops in the corona can be formed in two fundamentally different ways. The first involves twisting the lines of an existing potential field by vortical plasma motions on the photosphere, i.e., by poloidal field injection. The second mechanism involves the emergence of both toroidal field and toroidal current simultaneously from the photosphere. In the first case, we start with a bipolar potential field, with a surface vortex in each pole rotating with the same direction and speed. A current-carrying field appears first at low altitude. It rises rapidly into the corona as current increases and the loop expands. If the overlying corona has a background field, the rising flux interacts with the background by forming a shear layer in between. Eventually, reconnection takes place in this layer and can provide the trigger for a solar flare. In the second mechanism, we model the emerging flux by specifying the normal components of the magnetic field and the current on the photosphere. The rising field and current develop into a sheared bipolar structure, as is observed.
*Supported, in part, by NSF, NASA, AFPL and UCI.

SAMPEX OBSERVATIONS OF MULTIPLY CHARGED ACR IONS

B. Klecker, M. Oetliker and D. Hovestadt (Max-Planck-Institut für extraterrestrische Physik, D 85740 Garching, Germany)
J.B. Blake and M.C. McNab (The Aerospace Corporation, El Segundo, Ca 90245, USA)
G.M.Mason (University of Maryland,College Park, MD 20742 MD, USA)

Recent results from SAMPEX showed that Anomalous Cosmic Ray (ACR) oxygen at energies below about 20 MeV/nucleon is predominantly singly ionized whereas at higher energies charge states ≥ 2 dominate. We report on new measurements of ACR O, N, and Ne obtained with the HILT sensor on SAMPEX in the energy range 8 to 28 MeV/nucleon, i.e. at energies where the transition between predominantly singly and multiply charged ions occurs. The observations show that at the higher energies also ACR N and Ne are multiply charged. The results will will be discussed in terms of charge exchange and acceleration time scales in the outer heliosphere.

ANISOTROPY OF GALACTIC COSMIC RADIATION AS PREDICTED BY THEORY OF MODULATION

Z. Kobyliński

1 *Institute of Mathematics and Physics of Siedlce University, Siedlce, Poland*

We investigate the influence of different geometries of the heliosphere on the components of anisotropy vector in the interplanetary space. The basical model: spherically symmetric heliosphere with termination shock at 100 AU and the solar wind speed assumed 400 km/s in the equatorial plane, increasing to 720 km/s in polar regions. This model is compared with results for polewardly elongated heliosphere and with the case, when the boundary is elongated opositelly to the proper motion of the solar system in Our Galaxy. Numerical solutions of the Fokker-Planck equation are obtained with assumption of following relation between parallel diffusion coefficient $K_{||}$ and rigidity R: $K_{||} \propto R$.

MAGNESIUM ISOTOPE ABUNDANCE MEASURED WITH SOHO/CELIAS/MTOF

H. Kucharek[1], F.M. Ipavich[2], R. Kallenbach[3], F.Gliem[4], H. Grünwaldt[5], M. Hilchenbach[5], B. Klecker[1], P. Bochsler[3], D. Hovestadt[1] and the CELIAS Team
([1]Max-Planck-Inst. f. extraterrestrische Physik D-85740 Garching, Germany)
([2]Dep. of Phys., Univ. of Maryland, MD 20742, USA)
([3]Phys. Inst. der Univ. Bern, CH-3012 Bern, Switzerland)
([4]Inst. f. Datenv., TU Braunschweig, D-38023 Braunschweig, Germany)
([5]MPI. f. Aeronomie, D-37819 Katlenburg-Lindau, Germany)

Coronal heating and solar wind acceleration are basically unsolved questions in solar physics. Element and isotope composition measurements in the interplanetary medium can provide important information about the origin of the solar wind. The results of such measurements will give us important information about the physical processes which transport the neutral atoms from the photosphere via the chromosphere to the corona of the Sun and how they get ionized and accelerated. The Charge, Element, Isotope Analysis System (CELIAS) on the SOHO satellite is designed to study the composition of the solar wind and of solar energetic particles. It consists of three time-of-flight spectrometers to perform composition measurements. The CELIAS solar wind mass spectrometer MTOF (MASS Time-of-Flight) has a very high time- and mass resolution and is therefore an excellent tool for isotope abundance measurements. We will present first results on the abundances of Magnesium isotopes measured in the solar wind.

ON THE SCENARIO OF GENERATION OF SOLAR DECIMETRIC SPIKES ON MASER CYCLOTRON RESONANCE.

A.A. Kuznetsov and V.G. Vlasov (Irkutsk State Technical University, 83 Lermontov Str., Irkutsk 74, 664074, Russia)

Solar spikes are radiation with duration 100 ms or less in the frequency range $300 \div 8000$ MHz with brightness temperature up to 10^{15} K. They are generated in t he active regions of corona. The analysis of simultaneous observations of decimetric spikes and flare X-rays with employing the theory of generation of radioemission on maser cyclotron resonance in inhomogeneous plasma, developed by one of the authors, is done. It is shown that for generation of spikes the density of electron beams about 10^2 cm^{-3} is enough. It is much less than density of flows of electrons, causing X-ray emission ($10^8 \div 10^9$ cm^{-3}). Thus, unstable on maser cyclotron resonance electron beams must represent an extremely small part of the flare electron flow. Generation of waves by such beams occurs only in those areas of magnetic loop, where small-scale inhomogeneity of plasma density with characteristic scale of 1000 km or less exists. In other areas of loop, where such small-scale inhomogeneity does not present, these electron beams are stabilized by monotonic inhomogeneous magnetic field of loop. In this scenario the temporal and spectral fine structure of spikes are reflection of complex dynamics of small-scale inhomogeneities in flare loops.

SECTOR STRUCTURE OF INTERPLANETARY MAGNETIC FIELD FROM PHOBOS 1, 2 MEASUREMENTS

T. V. Kuznetsova, L. B. Tsirulnik, V. A. Styazkin (IZMIRAN, 142092, Troitzk, Moscow region, Russia)
J. Rustenbach (Max-Planck-Institut für extraterrestrische Physik, Außenstelle Berlin Rudower Chausseee 5 D-12489 Berlin, Germany)

Sector structure of IMF measured by Phobos in 1988 - 1989 is studied. Calculatec spectra of the IMF are used for study. Solar activity had its peak of cycle 22 in 198 March when Phobos-2 was near Mars. Calculated spectra have a half the solar rotatio period. It is shown that the period is not due to a mathematical artefact, but reflects 2 sector structure of the IMF for this time. We show that the appearance of this periodicit can be explained by two active solar longitudes approximately 180 degrees apart.

PLASMA IRREGULARITIES IN THE SOLAR PHOTOSPHERE

Yu.V. Kyzyurov, S.F. Nosov (Main Astronomical Observatory, Kiev-22, 252650, Ukraine)

In the present report the process of generation of plasma irregularities (with scales smaller than the photosphere thickness) in a weakly ionized gas of the quiet solar photosphere is considered using a fluid model in which the plasma density is a passive scalar field and the velocity field of an incompressible neutral gas is a turbulent one. Our treatment takes a background gradient of ionization and a constant uniform magnetic field into account. To derive an equation relating the spectra of the plasma density fluctuations and the turbulent velocity field a renormalization theory method is applied. The approximate analytic expression for the power spectrum of plasma irregularities is obtained at second order in renormalized perturbation theory. It is shown that the spectrum of the photo- spheric irregularities is close to a power-law dependence and some its departures from a simple power law with a constant power index may exist.

A GENERALIZED MODEL FOR THE PROTON EXPANSION IN SOLAR WIND.

F. Leblanc and D. Hubert (Département de Recherche Spatiale, CNRS URA 264, Observatoire de Paris, 92195 Meudon Cedex, France.)

We construct a new approach to model the Velocity Distribution Function (VDF) for the protons in stellar atmosphere expansions or planetary polar winds. The generalized Grad's method of construction is used and comparisons with the bi-Maxwellian polynomial expansion model are made in applications to the solar wind in the context of the measurements made by the Helios probes between 0.3 AU and 1 AU. A fitting procedure based on a sum of two Maxwellian functions is used to check the convergence property of both polynomial expansions and to calculate the predicted polynomial expansion profiles along the magnetic field orientation for a typical proton VDF in the solar wind. The generalized model is better adapted than the bi-Maxwellian polynomial expansion function to reproduce the long tail features of a majority of the observed proton VDF; moreover our model does not display negative values of the VDF contrary to the bi-Maxwellian expansion for normalized heat flux larger than unity. A 16-moment approximation, which corresponds to a 3rd order of development, allows us to provide an associated set of generalized transport equations better closed than the equivalent system associated with a bi-Maxwellian polynomial expansion.

HELIOSPHERIC RESULTS FROM THE ULYSSES UNIFIED RADIO AND PLASMA WAVE EXPERIMENT

R.J. MacDowall (NASA/Goddard Space Flight Center, Greenbelt, MD 20771 USA; email address: macd@leprjm.gsfc.nasa.gov)

The Ulysses spacecraft has completed its first orbit, which is highly-inclined to carry it over the poles of the Sun with aphelion at ~1.3 AU and perihelion at ~5.4 AU. The data from this orbit provides the opportunity to compare wave activity along the southern segment of the orbit (1993-1994) with that of the northern segment (1995-1996). We will review some of the interesting differences seen in the data from the Unified Radio and Plasma Wave Experiment (URAP). Particular emphasis will be placed on the variety of phenomena - shocks, corotating interaction regions, and coronal mass ejections - that exhibit particular plasma wave behaviors. Radio wave observations from URAP permit the monitoring and tracking of solar type II and type III radio bursts. Recent results from the radio data observations, including measurements of the sizes of shock-associated radio emitting regions will presented.

CONNECTION OF SOLAR WIND TO THE CHROMOSPHERIC NETWORK

J.F. McKenzie, W.I. Axford and G.V. Sukhorukova (Max-Planck-Institute für Aeronomie D-37189 Katlenburg-Lindau, Germany)

It is generally acknowledged that high speed solar wind emanates from coronal holes. Here we discuss how the wind is connected to the chromospheric network pattern through magnetic funnels, at the feet of which are located thin (a few tens of km) ionizing layers. The flow and temperature structure in the funnel is analyzed on the basis of downward heat conduction from the corona balancing upward advection of enthalpy and kinetic energy. We show that the flow in the funnel remains subsonic provided the downward heat flux from the coronal base is sufficiently intense, otherwise the flow is choked or exhibits a critical supersonic-subsonic transition. The ionization layer caused by electron impact is located at about 4.5 chromospheric scale heights below the base and its structure is that of a weak deflagration.

Diagnostics of densities and abundances in coronal streamers

L. Maccari et al. (UVCS/SOHO team)

This paper studies the space distribution of the total intensity of some ion lines observed by UVCS. The UVCS measurements show that in most streamers the ratio between the intensity in the OVI resonance doublet and that in the HI Lyman-alpha line is not constant in space. This occurs also for the ratio to Lyman-alpha of the lines of other coronal ions. One interpretation is that this phenomenon is due to variations in the elemental abundances. This possibility and its implications, including the interplanetary abundances, are discussed in this paper.

NUMERICAL MODELING OF COMPRESSIVE FLUCTUATIONS IN THE SOLAR WIND

F. Malara and P. Veltri (Dipartimento di Fisica, Universitá della Calabria, 87030 Rende (CS), Italy)
L. Primavera (Astrophysikalisches Institut, Postdam, D-14482 Germany)

The heliospheric current sheet embedded in solar wind slow speed streams represents a source for both compressive fluctuations and Alfvénic decorrelation in the low-frequency turbulence. We study the generation of compressions and the relative spectra, as well as the resulting ρ-B correlation in presence of a large scale current sheet. The nonlinear 2.5-D MHD equations are numerically solved in a cartesian geometry. The initial condition represents two streams of oppositely correlated large-amplitude Alfvénic fluctuations, converging on the two sides of the heliospheric current sheet. Compressive fluctuations are generated by two different mechanisms: a) propagation of Alfvénic fluctuations in the inhomogeneity associated with the large scale current sheet; b) interaction between oppositely correlated Alfvénic fluctuations, coming in contact in the current sheet. Both positive (fast mode) and negative (slow mode) correlated ρ-B fluctuations are generated in the current sheet, their subsequent behavior being dependent on the value of the plasma β. The ρ-B correlation as a function of the fluctuation scale, of location and of the plasma β reproduces well the corresponding quantity calculated from spacecraft data in slow speed streams. Power spectra of ρ, B, and inward and outward propagating Alfvénic fluctuations as they result from the model show features similar to those observed in solar wind data, both in the current sheet and far from it.

COMPRESSIVE WAVES IN COSMIC DUSTY PLASMA SYSTEMS

L. Mann and J.F.M. McKenzie (Max-Planck-Institut für Aeronomie, Postfach 20, D-37189 Katlenburg-Lindau, Germany)

We describe the interaction of a plasma with electrically charged cosmic dust particles within the framework of multicomponent hydrodynamics. In order to account for the different size distributions and electric grain charges we consider two dust components: small dust particles with a low charge but relatively high charge to mass ratio and bigger grains with a very small charge to mass ratio but a higher net electric charge. The resulting set of equations can be applied to different systems in interplanetary space. For example in the case of the near solar dust and its interaction with the solar wind compressive perturbations can be driven unstable by the cross beam configuration arising from the Keplerian motion of the dust and the radially outward motion of the wind.

SOLAR WIND AND CHROMOSPHERIC NETWORK

E. Marsch (Max-Planck-Institut für Aeronomie, Postfach 20, D-37189 Katlenburg-Lindau, Germany)
C.-Y. Tu (Department of Geophysics, Peking University, Beijing, 100871, China)

A physical model of the transition region, including upflow of the plasma in magnetic field funnels that are open to the overlying corona, is presented. A numerical study of the effects of Alfvén waves on the heating and acceleration of the nascent solar wind originating in the chromospheric network is carried out within the framework of a two-fluid model for the plasma. It is shown that waves with reasonable amplitudes can, through their pressure gradient together with the thermal pressure gradient, cause a substantial initial acceleration of the wind to locally supersonic flows in the rapidly expanding magnetic fields. The concurrent proton heating is due to the energy supplied by cyclotron damping of the high-frequency Alfvén waves, which are assumed to be created through small-scale magnetic activity, enforced by convective collisions and reconnections of magnetic flux tubes on scales of arcsec (700 km) size or smaller. The wave energy flux of the model is given as a condition at the upper chromosphere boundary, located above the thin sheet where the first ionization of hydrogen takes place. Alfvén waves with an assumed f^{-1} power spectrum in the frequency range from 1 to 10^4 Hz, and with an integrated mean amplitude ranging between 25 and 75 km/s, can produce very fast acceleration. Wave effects can heat the lower corona to a temperature of 5×10^5 K and accelerate the flow to speeds of up to 150 km/s at 12000 km.

RESULTS FROM JOINT SOHO-YOHKOH OBSERVATIONS

P.C.H. Martens (ESA SSD at Goddard Space Flight Center, SOHO-EAF, Code 682.3, NASA-GSFC, Greenblet, MD 20771, USA)

SOHO (the Solar and Heliospheric Observatory) has been carrying out regular science observations since April 1996. In this short period dozens of coordinated observing campaigns have been performed with Yohkoh, often with additional support from ground based observatories and other spacecraft.
It is clear that these joint observations have the potential of shedding light on several basic problems of Solar Physics, such as the detailed structure of soft X-ray emitting coronal loops, that are observed in broad-band by Yohkoh/SXT, and in 4 narrow-band filters by SOHO/EIT, with the same high spatial resolution.
Combined imagery of Yohkoh/SXT and the SOHO coronographs, LASCO and UVCS, allows, for the first time, the inspection of the magnetic field topology all the way from the solar limb out to 30 solar radii.
The analysis of the data from the joint observations between SOHO and Yohkoh is focused in a series of semi-annual collaborative data analysis workshops, the first of which will be held in March 1997 at GSFC. The subject of the first workshop is the joint observations of filament eruptions, flares and CME's, in the fall of '96, some of which have been made as part of IACG Campaign number 3.
I will present an overview of the joint observing campaigns to date, discuss the results of the first SOHO-Yohkoh workshop, and summarize the various ways and means by which SOHO data can be obtained for scientific analysis.

COSMIC RAY DIFFUSION IN SMALL-SCALE RANDOM AND MODERATE REGULAR MAGNETIC FIELDS

Yu. P. Melnikov (Rybinsk State Aviation Technology Academy,Pushkin st.53,152934 Rybinsk,Yaroslavl' Region,Russia)

The kinetic equation with the small-scale collision integral is solved in the diffusion approximation.The first three terms of expansion over parameter L/R,where L-correlation length and R -Larmor radius of particles in regular magnetic field,are taken into account in the collision integral.The spatial diffusion tensor is considered.The longitudinal component of the diffusion tensor is smaller as compared with longitudinal component for L/R=0,at momentum p=>0.The perpendicular component of the diffusion tensor is more as compared with this component for L/R=0,at p=>0.Thus,the isotropization of the diffusion tensor grows with the parameter L/R.

MEAN FREE PATH OF CHARGED PARTICLES WITH MODERATE AND STRONG RANDOM SCATTERING

Yu.P. Melnikov (Rybinsk State Aviation Technology Academy,Pushkin st.53,152934 Rybinsk,Yaroslavl' Region,Russia)

The equations for the exact averaged Green function and the exact vertex operator are derived and solved for the case of strong and moderate small-scale random scattering. The diagramm technique is employed to detetermine the main processes of moderate and strong small-scale scattering and find the corresponding collision integrals, wich are then used to obtain the kinetic and diffusion equations for the averaged distribution function.The mean free path has the form l=a*L+R*(b+c*R/L), at R>L,where L-correlation length, a,b,c-some functions of spectral index, R-Larmor radius of particles in the random magnetic field.The mean free path is proportional to 1/R,at R<<L.

EISCAT OBSERVATIONS OF TRANSIENT EVENTS IN THE SOLAR WIND.

PJ Moran, AR Breen, CA Varley, WP Wilkinson, PJS Williams (Physics Department, University of Wales Aberystwyth, SY23 3BZ, UK)
WA Coles, RR Grall, MT Klinglesmith (Department of Electrical and Computer Engineering, University of California San Diego, California, USA)
J. Markkanen (EISCAT Sodankylä, SF-99600, Finland.)

Observations of interplanetary scintillation (IPS) using the three widely separated antennas of the EISCAT facility provide accurate measurements of solar wind velocities at distances from the Sun between 15 and 130 solar radii. At distances greater than 6 solar radii the flow vector of the solar wind is expected to be in the radial direction. IPS measurements made when the observational geometry is changing rapidly can be used to test this hypothesis. The majority of observations indicate flow directions very close to the radial, but some observations suggest a small off-radial component of flow.
Coronal mass ejections (CMEs) are one of the main causes of disturbances in the heliosphere. At the leading edge of a CME, the magnetic field is perpendicular to the direction of flow, producing a characteristic and identifiable signature in IPS measurements. We present a summary of observations of CMEs between 1990 and 1996.

PRELIMINARY RESULTS OF COORDINATED GROUNDBASED AND SOHO OBSERVATIONS OF THE SOLAR CHROMOSPHERE AND TRANSITION REGION

K.Muglach(1), U.Schühle(2), F.Stolpe(3), K.Wilhelm(2), W.Schmidt(4), M.Knölker(5)

(1) ESA Space Science Department, ESTEC, Keplerlaan 1, NL-2201 Noordwijk, The Netherlands
(2) Max-Planck-Institut für Aeronomie, D-37191 Katlenburg-Lindau, Germany
(3) Universitäts-Sternwarte Göttingen, Geismarlandstraße 11, D-37083 Göttingen, Germany
(4) Kiepenheuer Institut für Sonnenphysik, Schöneckstraße 6, D-79104 Freiburg, Germany
(5) High Altitude Observatory, NCAR, Boulder, CO, 80307-3000, USA

In September 1996 high resolution spectroscopic observations of the sun were carried out at the German Gregory Coudé Telescope in Tenerife together with the SUMER instrument onboard of SOHO. The spectra include visible and near infrared lines as well as UV lines thus covering a range of height between the solar photosphere and the transition region.
The program consisted of two parts: a) large spatial scans of about 100 arcs were made to give synoptic maps at different heights in the solar atmosphere and b) time sequences of slit spectra were obtained to study dynamic events. In our contribution we will present first results of the synoptic program.

SOLAR CORONA DURING THE LAST 14 SOLAR CYCLES

K. Mursula (Univ. of Oulu, Dept. of Physical Sciences, FIN-90570 Oulu, Finland)
B. Zieger (Geod. and Geophys. Res. Institute, Hungarian Acad. of Sciences, Sopron, Hungary)

We have recently (1) examined the occurrence of the half solar rotation (13-14 days) periodicity in solar wind, IMF and geomagnetic activity over the last three solar cycles. Large amplitudes of this periodicity are due to the existence of two high-speed streams, and the related times can be identified with solar excursion phases. For the last three solar cycles, the excursion phases occurred in the mid- to late declining phase. Now, using the excellent correlation between the geomagnetic variables and the solar wind speed, we have extended our study to cover the last 14 solar cycles. We have determined the intensity and timing of the solar excursion phases for these cycles. Notable differences are observed between the most recent and the earlier cycles. E.g., during some of the cycles, the excursion phase occurred close or at the solar maximum. The results demonstrate great differences in the 11-year cycle of the solar corona during the last 150 years.
(1) K. Mursula and B. Zieger, J. Geophys. Res., 101 (A), 27077-27090, 1996.

Alfven Surface Waves in Cylindrical Tubes with Non Uniform Magnetic Fields

A. Satya Narayanan, Indian Institute of Astrophysics, Bangalore - 560 034, India

The Surface Magnetic Field of the Sun is made up of intense,isolated Flux Tubes situated at Supergranular Boundaries. Flux Tubes play an important role in transporting energy from the surface to the atmosphere of the Sun. It is well known that Surface Waves are two dimensional and therefore their propagation characteristics, in general, can be affected by the surface geometry. In this study we are interested in studying Alfven Surface Waves along Cylindrical Tubes of uniform plasma density surrounded by a plasma of different density. The basic magnetic field surrounding the plasma column is assumed to be uniform while the magnetic field inside the cylindrical tube is non uniform. The symmetric (m=0) and asymmetric (m=1) modes are highly dispersive. The condition for the existence of these modes is discussed. Limiting cases of the plasma parameteres is discussed. There exists a critical wavenumber wherein the modes change from backward to forward waves and vice-versa. The normalized phase speed of these modes depend on the ratio of the densities, the magnetic fields. Finally, it is shown that this configuration is stable to small perturbations.

Results from the SOHO/UVCS Ultraviolet Coronagraph Spectrometer

G. Noci et al. (UVCS/SOHO team)

We present the first results obtained by the Ultraviolet Coronagraph Spectrometer (UVCS) operating on board the SOHO satellite. The UVCS started to observe the extended corona at the end of January 1996; it routinely obtains coronal spectra in the 1145 \AA~- 1287 \AA, 984 \AA~- 1080 \AA~ranges, and intensity data in the visible continuum. Through the composition of slit images it also produces monocromatic images of the extended corona. The performance of the instrument is excellent and the data obtained up to now are of great interest. We briefly describe these data and discuss some implications for our knowledge of the physical properties of the solar corona. The paper will examine, in particular, the very large r.m.s. velocities of the ions in polar holes and the difference between the HI Lyman-alpha image of streamers and that in the OVI resonance doublet.

ACR ELEMENTAL ABUNDANCES OF C, N, O, AND NE MEASURED WITH HILT ON SAMPEX

M. Oetliker and G.M. Mason (University of Maryland, College Park MD 20742)
B. Klecker (MPI für extraterrestrische Physik, D-85740 Garching, Germany)
J.B. Blake and M.C. McNab (Aerospace Corporation, El Segundo CA 90245)

With the HILT sensor on SAMPEX we measure the abundance of carbon, nitrogen, and neon relative to oxygen in the anomalous component of cosmic rays (ACR) in the energy range 7-25 MeV/nuc. We use a trajectory tracing code for the magnetosphere to infer the charge of the particles from their measured mass, energy and direction of incidence. The ACR abundance of each species is deduced from the occurrence of low charge states ($Q < 4$) to exclude other contributions of e.g. highly ionized solar or interplanetary particles.
Our preliminary results for the ACR abundances are: $C/O = 2.0 \pm 2.9\%$, $N/O = 16.5 \pm 4.0\%$, and $Ne/O = 5.1 \pm 1.6\%$. The abundance of ACR carbon is of special interest, as carbon with its low first ionisation potential is expected to be predominantly ionized in the local interstellar medium (IM), the source of the ACR. Contrary to other species like nitrogen, oxygen, and neon (mostly neutral in the IM), the charged carbon can not penetrate into the heliosphere. Low abundances of ACR carbon were also measured in the outer heliosphere with the Voyager spacecraft ($C/O \approx 1\%$). In previous measurements at 1 AU higher values of typically $\approx 10\%$ were obtained, possibly due to contributions of heliospheric origin, excluded with the selection of low charge states in our measurements.

FIRST YEAR SOLAR EUV IRRADIANCES FROM SOHO BY THE CELIAS/SEM

H. S. Ogawa, D. L. Judge, D. R. McMullin and P. Gangopadhyay (Space Sciences Center, University of Southern California, Los Angeles, CA 90089-1341, USA)

The Celias/SEM instrument aboard SOHO has been continously monitoring the full disk absolute EUV irradiance at 30.4 nm and the full disk absolute irradiance integrated between 0.1 nm to 77 nm. First light was obtained on December 16, 1995 and the CELIAS/SEM has been successfully operating providing high quality solar EUV irradiances data from the L-1 Lagrange point since then. The Data have been placed on an absolute scale based on the initial calibration of the CELIAS/EUV instrument and a calibration rocket underflight on June 26, 1996 using an "identical" SEM instrument. The long term CELIAS/SEM data and associated analyses will be presented.

Evolution of MHD Waves in Coronal Loops

B. P. Pandey and G. S. Lakhina, Indian Institute of Geomagnetism, Colaba, Bombay 400 005, INDIA

Solar coronal plasma, modelled generally by a low beta, resistive plasma slab, sustains MHD wave propagations due to footpoint motions in the photosphere. The numerical simulations presented here focus on the evolution of the Alfven, fast and slow waves in coronal loops. The plasma responds to the footpoint motion by kink or sausage waves depending on the amount of shear in the magnetic field. The larger twist in the magnetic field of the loop introduces more fast wave trapping and destroys initially developed sausage-like wave modes. The slow waves develop more complex fine structures, thus accounting for several local extrema in the perturbed velocity profiles in the loop. Increasing the twist leads to a higher heating rate of the loop.

MHD study of coronal waves: A numerical Approach

S. Parhi*, M. Goossens**, G. S. Lakhina* and P. De Bruyne**
*Indian Institute of Geomagnetism, Colaba, Bombay 400 005, INDIA
**Center for Plasma Astrophysics, K. U. Leuven, Celestijnenlaan 200B, B-3001 Leuven, Belgium

The solar corona, modelled by a low beta, resistive plasma slab sustains MHD wave propagations due to footpoint motions in the photosphere. The density, magnetic profile and driver are considered to be neither very smooth nor very steep. The numerical simulation presents the evolution of MHD waves and the formation of current sheet. Steep gradients in slow wave at the slab edges which are signature of resonance layer where dissipation takes place are observed. Singularity is removed by the inclusion of finite resistivity. Dissipation takes place around the resonance layer where the perturbation develops large gradients. The width of the resonance layer is calculated. The thickness of the Alfven resonance layer is more that that of the slow wave resonance layer. Attempt is made to distinguish between slow and Alfven wave resonance layers. Fast waves develop into kink modes. As plasma evolves the current sheets which provide the heating at the edges gets distorted and fragment into two current sheets at each edge which, in turn come closer when the twist is enhanced.

FAST DISSIPATION OF ALFVÉN WAVES IN 3D INHOMOGENEOUS MAGNETIC FIELDS

Panagiota Petkaki, Francesco Malara, Pierluigi Veltri and Gaetano Zimbardo and (Dipartimento Di Fisica, Universita' della Calabria, Arcavacata Di Rende, 87030, Italia)

The dissipation of a large number of Alfven wave packets propagating in an inhomogeneous 3-D magnetic field is numerically studied in the WKB approximation The dissipation rate is found to scale proportional to the logarithm of viscosity and/or resistivity, i.e. much faster than the scaling found for 2-D configurations (phase-mixing). This phenomenon is related to the exponential separation of neighbouring rays; estimations of the corresponding rate are consistent with the behavior of the Kolmogorov entropy in this kind of structures. This study can apply to the heating of low collision plasmas, e.g. in astrophysical contexts

GYROSCOPIC WAVES IN THE BASE OF THE SOLAR CORONA: MODELING AND POSSIBLE OBSERVATIONAL MANIFESTATIONS.

Yu.V. Pisanko (Institute of Applied Geophysics, Rostokinskaya st.9, Moscow 129128, Russia)
V.P. Tritakis (Research Center for Astronomy and Applied Mathematics, Academy of Athens, 14 Anagnostopoulou str., Athens 10673, Greece)

A solution of MHD equations is proposed for gyroscopic waves in the base of the solar corona. The waves move slowly around the Sun along heliolatitude circles. The shortest wave period is equal to the period of the solar rotation. Coronal material motions in the waves have cyclonic and anticyclonic character. The differential rotation of the coronal base is also contained in the solution. North-south and east-west asymmetries of the red (FeX,637,4 nm) coronal emission line and the fact (Trellis,M.: 1960, Compt.Acad.Sci.Paris, 250,58) that the red line corona is fainter on the solar side facing the Apex could be interpreted as possible observational manifestations of the gyroscopic waves phenomenon in the coronal base. The satisfactory agreement (the order of magnitude) between asymmetry coefficient values calculated from observational data and, independently, from the theoretical model could testify to the correctness of the above interpretation.

NUMERICAL SIMULATIONS OF SPICULES DRIVEN BY DAMPING OF ALFVÉN WAVES

B. De Pontieu and G. Haerendel (Max-Planck-Institut für extraterrestrische Physik, D-85740 Garching-bei-München, Germany)

We present the results of two kinds of time-dependent numerical simulations of t he formation of chromospheric spicules based on damping (due to ion-neutral collisions) of upwar d propagating Alfvén waves. In both models we study a vertical flux tube which fans out with height, at the base of which we generate (upward travelling) Alfvén waves. In a first model we employ the WKB-approxima tion to study only wavelength-averaged Alfvén wave properties. This allows us to take more e laborate approaches towards the ionization (such as non-LTE for hydrogen) and radiation transfer (su ch as optically thick in two emission lines) in the flux tube. The second model lacks these elaborate approac hes, but is based on 1.5 D MHD equations and thus allows the study of shocks in the flux tube. By combining the results of both models, we find that Alfvén waves with frequencies in the range 0.2 to 1 Hz can form structures of which the temperatur e, density, vertical velocity profile and maximum height agree very well with the (observed) values for spicul es. The MHD model indicates that the upward spicular motion is supported by the wav e damping by ion-neutral collisions, but also by the formation and upward propagation of slow shocks. The results are very robust with respect to the various ionization and radiation transfer approaches used. This is due to the critical dependence of the momentum transfer and heating mech anism on the presence of neutrals.

Possible role of whistler-mode wave emission on the electron heat flux regulation in the solar wind using Ulysses data.

F. Pierre[1], J. Solomon[1,2], N. Cornilleau-Wehrlin[2], P. Canu[2] ([1]IAS/CNRS/Univ. Paris 11, Orsay and [2]CETP/CNRS, Vélizy, France)
E. E. Scime (Dept of Physics, West Virginia University, Morgantown, West Virginia, USA)
A Balogh and R. J. Forsyth (Imperial College of Science and Technology, Londo n, England)

¿From the electron distribution functions (EDF) in the energy range 1.6 to 862 eV obtained from the Ulysses' plasma experiment (SWOOPS), we compute the wave growth rate of the electromagnetic electron cyclotron and landau modes for the case of propagation of the waves at any angle with respect to the interplanetary magnetic field (IMF) B. Results of the calculations are in general agreement with the magnetic wave spectra measured by the Ulysses' wave experiment (URAP) in the frequency range 0 22-448 Hz, particularly downstream of interplaneta ry shock waves. We then examine whether: (i) the instability can be due to heat flux asymmetry of the EDF with respect to the IMF B and/or to a temperature anisotropy of the EDF; (ii) velocity space diffusion of the core and halo electrons by the emitted waves can regulate the electron heat flux.

ANOMALOUS DIFFUSION OF MAGNETIC FIELD LINES AND ENERGETIC PARTICLE EVENTS AT HIGH HELIOGRAPHIC LATITUDES

P. Pommois, P. Veltri and G. Zimbardo (Dipartimento di fisica , Università della Calabria, I-87030 Arcavata di Rende, Italy.)

The Ulysses spacecraft detected recurrent energetic particle events at high solar latitudes (about 70°). It is commonly held that these phenomena are originated in proximity of corotating interactions regions (CIRs), that should not extend to latitudes higher than 30°. We study here numerically the random walk of magnetic field lines, in the case that a power-law spectrum of magnetic fluctuation is superimposed to a background field. The simulation is three dimensional and the magnetic fluctuations are made anisotropic in order to reproduce what occurs in solar wind, where correlation lengths are typicaly higher in the direction normal to the ecliptic plane. We show that there is superdiffusion in this direction. Superdiffusion is characterized by Levy random walk and non Gaussian dynamics. We conclude that this large cross-field diffusion can be enough to permit the magnetic field line connection between CIRs and energetic particles at high latitudes.

FIRST YEAR OF OBSERVATION WITH SOHO/EIT OF THE "QUIET" SOLAR CORONA

F. Portier-Fozzani and A. Maucherat (Laboratoire d'Astrophysique Spatiale, Marseilles, France)
EIT team (different places around the world)

From January 1996 (EIT first light), the Extreme Ultraviolet Telescope aboard SOHO has already produced about 20000 wide-field images of the corona and transition region. Observations, made with four different emission lines (HeII, Fe IX/X, Fe XII, Fe XV), provides the global temperature distribution in the quiet corona, in the range 0.5 to 3×10^6 K. It shows also the different structures present in the corona with information about their topology.
The evolution of the corona during this first year of the SOHO mission reveals the non uniformity aspect of the corona -one side of the sun can have an active region while the other has nothing-. The apparition of new active region is non uniform with time too -sometimes they can appears by 1, 2 or 3 during a short time-. Then, there seems to be some links between active regions and equatorial coronal holes -On september there looks to be some process between open lines and loops upon coronal holes-. Finally, the rotation of the corona seems not to explain entirely the movement of some actives regions, we need then to add some magnetic phenomena to understand it (like reconnection).

LARGE SCALE ELECTRIC FIELDS IN SOLAR FLARE REGIONS

M. I. Pudovkin, S. A. Zaitseva and N. O. Shumilov (Institute of Physics, St. Petersburg State University, St. Petersburg, Russia 198904)
C.-V. Meister (Institute for Theoretical Physics and Astrophysics, Potsdam University, 14469, Germany)

A method of separating electric field in the flare region onto the potential and vortex (induced) parts is discussed. According to the proposed model, the motion of flare ribbons from the central line of the flare region is caused by the vortex component of the coronal electric field, while the motion of bright spots within the flare region in direction to the central line is driven by the potential component of that field.
Intensity of the both components of the flare region electric field is estimated to equal approximately 1–3 $V \cdot cm^{-1}$, which provides the input of the electromagnetic energy into the active region at a rate about 10^{10} $erg \cdot cm^{-2} sec^{-1}$.

THE STRUCTURE OF THE MODIFIED HELIOSPHERIC SHOCK RESULTING FROM THE COMBINED INFLUENCE OF PICK-UP IONS, ANOMALOUS AND GALACTIC COSMIC RAYS

J.A. le Roux (Institute for Physical Science and Technology, University of Maryland, College Park, MD 20742-2431, USA)
H. Fichtner (Institut für Astrophysik und Extraterrestrische Forschung der Univerität Bonn, Auf dem Hügel 71, D-53121 Bonn, Germany)

We have investigated the modification of the heliospheric shock in upwind direct ion caused by suprathermal Pick-Up Ions, Anomalous and Galactic Cosmic Rays. For the
modulated cosmic ray spectra, obtained from a self-consistent time-dependent mod el based on the cosmic ray transport equation and the solar wind fluid equations, we could identify two solutions consistent with the in-situ observations made by
Voyager 2 and Pioneer 10 during the solar activity minimum in 1987. While the fi rst solution is characterized by a low injection efficiency of Pick-Up Ions into the process of diffusive shock acceleration and the structure of the heliospheric sh ock is mainly determined by those particles, the second alternative corresponds to a high injection efficiency and is dominated by Anomalous Cosmic Rays.

MECHANISMS OF ENHENCEMENT OF THE 'SOLAR' HE^+ ION ABUNDANCE IN THE EXPANDING SOLAR WIND

Daniel Ruciński and Maciej Bzowski (Space Research Centre of the Polish Academy of Sciences, Bartycka 18 A, 00-716 Warsaw, Poland)
Hans J. Fahr (Institut für Astrophysik und Extraterrestrische Forschung der Universität Bonn, Auf dem Hügel 71, D53121, Bonn, Germany)

The equilibrium models of the $\sim 10^6$ K solar corona predict that the solar wind in quiet conditions may contain only remnant He^+ component with relative abundance of $\sim 10^{-5}$ in comparison to the original solar wind α population. The early determinations of the solar He^+/He^{++} ratio for the standard solar wind based on the Vela 5 and 6 observations and especially recent long-term (1991–93) SWICS measurements from Ulysses suggest noticeable enhancement (by up to one order of magnitude) of the solar He^+ abundance in comparison to those theoretical predictions. In the paper we study possible mechanisms leading to such systematic increase of the 'solar' He^+ content, such as decharge of solar wind α particles due to charge-exchange with neutral interstellar H and He atoms and with dust desorbed H atoms and H_2 molecules, radiative recombination of solar wind alphas and the ionization of the helium component of the Neutral Solar Wind. It is shown that that inside/around 1 AU the recombination is the dominant mechanism enhancing He^+ abundance, while beyond $\sim$ 2–3 AU the most important contribution comes fro m the conversion of solar wind alphas to He^+ ions by charge-exchange with interstellar H atoms. We prove that the amount of the newly created He^+ ions remains in good agreement with the determination of their abundances from Vela and Ulysses.

OBSERVATIONAL CONSTRAINTS ON THE ACCELERATION TIME OF ANOMALOUS COSMIC RAYS: A STUDY OF PIONEER 10 DATA

K. Scherer (Max-Planck-Institut für Aeronomie, P.O. Box 20, D-37189 Katlenburg-Lindau, Germany)
H. Fichtner (Institut für Astrophysik und Extraterrestrische Forschung der Univerität Bonn, Auf dem Hügel 71, D-53121 Bonn, Germany)

On the basis of cross-correlations of solar Lyman-α and cosmic ray data for the period from 1981-1987, recorded by instruments aboard Pioneer 10 during its interplanetary cruise, we derive constraints on the time required to accelerate pick-up ions to anomalous cosmic rays. The characteristic time for energization of these suprathermal particles at the heliospheric shock gives rise to different phase shifts of the correlation functions of the anomalous and galactic cosmic ray data with the solar Lyman-α radiation used as a proxy for the long-term solar activity. A systematically greater time lag for the case of anomalous cosmic rays is interpreted as their acceleration time, which in turn allows an estimate of the efficiency of spatial diffusion of energetic particles perpendicular to the magnetic field just upstream of the heliospheric shock at low heliographic latitudes.

A PULSAR, THE HELIOSPHERE AND PIONEER 10

K. Scherer (Max-Planck-Institut für Aeronomie, P.O. Box 20, D-37189 Katlenburg-Lindau, Germany)
H. Fichtner (Institut für Astrophysik und Extraterrestrische Forschung der Universität Bonn, Auf dem Hügel 71, D-53121 Bonn, Germany)
J. D. Anderson and E. L. Lau (Jet Propulsion Laboratory, M/S 301/230, Pasadena, CA, 91109-8099)

The timing data of the pulsar PSR1257+12 have been explained by orbital motion around the barycenter - defined by the pulsar and three planets [Wolszczan 1994]. To fit the data, planar three (four) body simulations were used to describe the planetary evolution over tens of years. Scherer et al. [1996] recognized a periodicity of 25.3 days in the Pioneer 10 (P10) Doppler data, a period which is essentially the same as the period of the third postulated planet around PSR1257+12. Both the P10 Doppler signal and the pulsar emission represent radio waves, whose propagation is affected by electron content of the solar wind plasma. The electron density varies periodically due to the solar rotation. This density variation can be observed indirectly via the proton data recorded by different spacecraft (P10, Voayger 2, IMP). In order to establish these connections, a cross correlation function (calculated with an FFT formalism) between the solar wind plasma data and the P10 Doppler data is compared with the autocorrelation function of the latter. We discuss the results.

SEISMIC OBSERVATION OF THE SOLAR INTERIOR FROM SOHO/MDI

P.H. Scherrer, R.S. Bogart, R.I. Bush, T.L. Duvall, Jr., J.T. Hoeksema, A.G. Kosovichev, and J. Schou (W.W. Hansen Experimental Physics Laboratory, Stanford University, CA 94305-4085, USA)

We present first results from three basic helioseismology programs of the Michelson Doppler Imager (MDI) instrument on board SOHO. Two of these programs, Low-l and Medium-l, designed to measure solar acoustic (p) modes up to the angular degree $l = 300$, have been run with almost no interruptions since 18 April 1996. The third program, Dynamics, which provides 1024×1024 pixel Doppler velocity and intensity images of the Sun, and covers p modes up to $l = 1500$, can run continuously for only 2 months each year when the high-rate telemetry channel is available. The first Dynamics Program run spanned the time period from 23 May through 24 July 1996.

The initial results show that the noise in the MDI oscillation power spectra is substantially lower than in ground-based measurements. This enables us to detect lower amplitude modes and to extend the range of measured mode frequencies. The sound-speed profile inferred from the mean frequencies of mode multiplets gives evidence for significant deviations from a standard solar model in the upper convective boundary layer, in a thin layer just beneath the convection zone, and in the energy-generating core. Inverting the multiplet frequency splittings, we detect strong rotational shear at the boundaries of the convection zone. We discuss in detail the properties of the shear layer at the bottom of the convection zone where the solar dynamo is likely to operate.

OBSERVATION OF METEOROIDS IN THE KUIPER BELT BY PIONEER 10 AND ITS IMPLICATIONS

K. Scherer (Max-Planck-Institut für Aeronomie, P.O. Box 20, D-37189 Katlenburg-Lindau, Germany)
J.D. Anderson and E.L. Lau (Jet Propulsion Laboratory, 4800 Oak Grove Drive, M/S 301/230, Pasadena, CA 91119, USA)
D.C. Rosenbaum and V.L. Teplitz (Department of Physics, University of Maryland, College Park, Md 20742, USA)

During the passage of Pioneer 10 through the Kuiper Belt (between 35 AU and 65 AU or more) discontinuities in the Doppler signal were recorded. These jumps in the signal corresponds to a velocity change of the spacecraft caused by impacts of Kuiper Belt meteoroids (KBM). The mass and size of four KBM's was analyzed. The spatial distribution of the KBM's seems to be located in discrete regions around mean motion resonances. The implications to the Kuiper Belt and planetary evolution will be discussed.

ULYSSES OBSERVATIONS OF VARIOUS HYDROMAGNETIC WAVES

E. J. Smith, M. Neugebauer, N. Murphy (Jet Propulsion Laboratory, 4800 Oak Grove Dr., M/S 169-506, Pasadena, CA 91109
A. Balogh (The Blackett Laboratory, Imperial College, London SW7 2BZ)
D. J. McComas (Los Alamos National Laboratory, MS D466, Los Alamos, NM 87545)

A characteristic feature of the fast, high latitude solar wind is the continuous presence of large amplitude Alfvén waves. Although the waves are outwardly propagating, the observed field vector executes a random walk over a hemisphere whose pole is the radial direction and whose sense corresponds with the dominant field polarity, positive in the north and negative in the south solar hemispheres. The waves very effectively oppose the entry of galactic cosmic rays into the polar regions and cause the average field direction to depart from the parker field orientation. Magnetosonic waves have recently been identified in the interaction regions accompanying high latitude microstreams, one of the few positive identifications which are enabling studies of such waves in the solar wind. Ion cyclotron waves having a left-handed (ion) polarization and frequencies very near the local proton gyrofrequency are seen sporadically in association with the pick-up of interstellar ions. Their intermittency and effect on the phase space distribution of the pick-up ions and the solar wind moments are of keen scientific interest. Recent observations and analyses of these various wave modes will be presented.

STRUCTURE OF A PHOTOIONIZATION LAYER IN THE SOLAR CHROMOSPHERE

G.V. Sukhorukova, J.F. McKenzie and W.I. Axford (Max-Planck-Institute für Aeronomie D-37189 Katlenburg-Lindau, Germany)

We analyze the steady structure of a photoionization layer in which a downward flux of EUV photons ionizes neutral elements flowing in a background of flowing hydrogen. The neutrals enter the layer at the hydrogen speed and the ions exit at the hydrogen speed and therefore there is no FIP effect. The model can be extended to a background containing a layer mixture of neutral hydrogen and protons. In this case the neutrals enter the layer at the hydrogen speed and their ionized counterparts exit at the proton speed so once again there is no FIP effect. These results support the contention that FIP effects can only arise in unsteady situations such as are believed to exist at the base of slow solar wind which is inherently unsteady, filamentary and not in equlibrium with its coronal base.

NUMERICAL SIMULATIONS OF NORTH-SOUTH ASYMMETRY IN ROTATION OF SOLAR MAGNETIC FIELDS

E.M. Tikhomolov (Institute of Solar-Terrestrial Physics, 664033 Irkutsk, P.O.Box 4026, Russia)

One of the most dramatic manifestation of the north-south asymmetry of the Sun is the appearance of different rotation periods of magnetic fields in different solar hemispheres. In our previous papers we suggested that a number of large-scale long-lived solar phenomena can be interpreted as a result of the excitation of the Rossby vortices in a thin layer below the convection zone. Here we show how the different rotation periods of magnetic fields can appear in the frame of our approach. Numerical simulations demonstrate a good correspondence to experimental data for 21st cycle of solar activity when at the initial instant Rossby anticyclone and cyclone are specified, respectively, in north and south hemispheres. Other situations are also discussed.

INJECTION AND INTERPLANETARY TRANSPORT OF SOLAR PROTONS AS OBSERVED BY ERNE

J. Torsti, T. Laitinen, L. Kocharov, A. Anttila, R. Vainio, E. Valtonen (Space Research Laboratory, Physics Department, FIN-20014 University of Turku)

Three energetic solar particle events were observed in 1996 by ERNE on board SOHO with observable proton flux above 30 MeV. The onset of events was at 10:15 on July 9th, 17.50 UT on August 13th, and at 19:50 UT on November 28th. The events had a rapid intensity increase at all energy channels from 1.6 MeV to more than 30 MeV. Two maxima in the proton intensity were observed during the Nov.28-Dec.1 event. In all cases a conspicuous solar activity region was located on the western hemisphere as observed by the SOHO coronagraphs. The event on July 9 was obviously associated with a solar flare. The maximum intensity in X-rays, X2.6, was detected by GOES 8 and 9 at 9:12 UT. The C1.3 flare observed at 17:32 UT on November 28 and the M1.0 flare observed at 20:44 UT on November 29 may be the source of the energetic protons detected. Instead, the X-ray intensity during the August particle event was extremely low. ERNE has a capability to observe the spatial development of the intensity profiles in the view cone of the sensors. An analysis of energetic particle injection and transport is presented. Special emphasis is paid on the flux anisotropies during the particle events.

TWO-FLUID MODEL FOR HEATING OF THE SOLAR CORONA AND ACCELERATION OF THE SOLAR WIND BY HIGH-FREQUENCY ALFVÉN WAVES

C.-Y. Tu (Department of Geophysics, Peking University, Beijing, 100871, China)
E. Marsch (Max-Planck-Institut für Aeronomie, Postfach 20, D-37189 Katlenburg-Lindau, Germany)

A model of the solar corona and wind is developed which includes for the first time the heating and acceleration effects of high-frequency Alfvén waves in th e frequency range between 1 Hz and 1 kHz. The waves are assumed to be generated by the small-scale magnetic activity in the chromospheric network. The wave dissipation near the gyro-frequency, which decreases with increasing solar distance, leads to strong coronal heating. The associated thermal pressure-gradient force and wave pressure-gradient force together can accelerate the wind to high velocities, such as observed by Helios and Ulysses. Classical Coulomb heat conduction is also considered and turns out to play a role in shaping the temperature profiles of the heated protons. The time-dependent two-fluid (electrons and protons) model equations and the time-dependent wave-spectrum equation are numerically integrated versus solar distance out to about 0.3 AU. The solutions finally converge and settle on time-stationary profiles which are discussed in detail. The model computations can be made to fit the observed density profiles of a polar coronal hole and polar plume.

CORONAL STREAMER SIMULATION: ALFVÉN WAVE ACCELERATION AND EXTENSION TO 1 AU

A. V. Usmanov (Institute of Physics, Univ. of St.-Petersburg, St.-Petersburg 198904, Russia)
B. P. Besser and J. M. Fritzer (Institute of Space Research, Austrian Academy of Sciences, Inffeldgasse 12, A-8010 Graz, Austria)

A self-consistent two-dimensional simulation of the plasma flow in a dipole magnetic field configuration is performed. The features of the present formulation are: (i) incorporation of the heat and momentum addition due to Alfvén waves propagating outward from the Sun and providing additional acceleration to the coronal plasma flow; (ii) extension of the computational domain out to 1 AU. The governing dissipationless single-fluid MHD equations adjusted for the equatorial plane are solved by employing a time-relaxation technique to obtain a steady-state solution in the near-sun (1–20 $R_\odot$) region. Then the solution is extended to 1 AU by means of a marching-along-radius numerical scheme. We assume $\gamma = 1.12$ and the Alfvén wave energy influx at the coronal base (1 $R_\odot$) varies from 0 to $3{\cdot}10^4$ erg cm^{-2} s^{-1} when the radial magnetic field increases from 0 to 4 G. We obtained the solution with the variation in the radial velocity and the number density at 1 AU from 350 to 640 km s^{-1} and from 13 to 4 cm^{-3}, respectively. At 1 $R_\odot$, the temperature is $\sim 1.8{\cdot}10^6$ K, the number density and the radial velocity vary from $1.2{\cdot}10^8$ to $7{\cdot}10^7$ cm^{-3} and from 0 to 9 km s^{-1}, respectively. We compare the solutions with and without Alfvén waves and show that those with waves are much more appropriate for reproducing observations both near the coronal base and at 1 AU.

RESULTS FROM THE SOHO/SUMER UV SPECTROMETER

K. Wilhelm and the SUMER Consortium
(Max-Planck-Institut für Aeronomie, 37191 Katlenburg-Lindau, Germany)

SUMER - the Solar Ultraviolet Measurements of Emitted Radiation investigation of the Solar and Heliospheric Observatory (SOHO) - observed its first light on January 24, 1996. The wavelength range extends from less than 500 Å to 1610 Å. Many features and areas of the Sun and their spectra have been observed since, including coronal holes, polar plumes and active regions. The atoms and ions emitting this radiation persist at temperatures below 2×10^6 K and are thus ideally suited to investigate the solar transition region where the temperature increases from chromospheric to coronal values. Detailed line profiles covering several spectral pixels with resolution elements between 22 and 45 mÅ can be produced at each spatial pixel for many lines. From the line widths, intensities and wavelength positions it is possible to deduce temperatures, densities, and velocities of the emitting atoms and ions.

FIRST DETERMINATION OF THE SOLAR WIND SILICON ISOTOPIC COMPOSITION: WIND/ MASS RESULTS

R. F. Wimmer-Schweingruber, P. Bochsler, O. Kern and R. Bodmer (Physikalisches Institut, Universität Bern, 3012 Bern, Switzerland)
G. Gloeckler, D. C. Hamilton and G. C. Ho (Dept. of Physics, University of Maryland, College Park, MD)

Silicon is a common material in the solar system. For instance, Si accounts for about 10 % of the material in primitive meteorites (C1 chondrites). Since silicon is a refr actory element we expect the meteoritic isotopic composition to be very similar to that of our Sun. The isotopic composition of Si in C1 chondrites is very well known. Thus the three stable isotopes of Si may serve as powerful tools to test models of solar wind fractionation.
We present, for the first time, measurements of the isotopic composition of Si i n the solar wind as obtained with the MASS instrument aboard the WIND spacecraft. We accumulated data in exceedingly cold and slow wind. Such wind is often associ ated with current sheet crossings which in turn are associated with the most efficient isotopic fractionation proc esses in the solar wind acceleration region.
Our results can thus serve as strict constraints on solar wind acceleration mode ls and put stringent limits on the isotopic fractionation between the solar surface and the interplan etary medium.

SOLAR WIND STREAM INTERFACES IN COROTATING INTERACTION REGIONS: SWICS/ULYSSES RESULTS

R. F. Wimmer-Schweingruber (Physikalisches Institut, Universität Bern, 3012 Bern, Switzerland)
R. v. Steiger (International Space Science Institute, 3012 Bern, Switzerland)
R. Pärli (Physikalisches Institut, Universität Bern, 3012 Bern, Switzerland)

Motivated by the well-known differences in charge-state and even elemental composition of the slow solar wind as compared to high-speed streams, we have an alysed observations made by the SWICS/Ulysses mass spectrometer of the series of corotating interact ion regions (CIRs) encountered by Ulysses in 1992/93 at 4.5 - 5.4 AU from the Sun. Stream interface s (SIs) are first identified within each CIR using the kinetic parameters - density and thermal sp eed - of the main components, protons and alpha-particles. We then show that SIs are also the loca tion of the expected compositional changes in the minor components, such as freezing-in temperatures of C and O and the strength of FIP fractionation as given by the Mg/O abundance ratio, to within th e time resolution with which these parameters may be obtained by SWICS. The changes in freezing-in temperatures are so clear that they in turn may be used as a robust indicator of the SI location and even reveal that some of the SI crossings were in fact multiple. We conclude that the "color" of the solar wind, i. e. its composition of heavy ions, changes abruptly at the SI and remains well preserved out to large heliocentric distances. No mixing of the two different solar wind types which me et in a CIR could be observed within the possible time resolution.

SWICS/ULYSSES OBSERVATIONS: THE THREE-DIMENSIONAL STRUCTURE OF THE HELIOSPHERE DURING SOLAR MINIMUM

J. Woch, I. Axford, U. Mall, B Wilken, S Livi (all at: Max-Planck-Institut für Aeronomie, D-37191 Katlenburg-Lindau)
J. Geiss (International Space Science Institute, CH-3012 Bern, Switzerland)
G. Gloeckler (University of Maryland, College Park, Maryland, 20742)

The Solar Wind Ion Composition Spectrometer SWICS aboard Ulysses provides in-situ observations of the three dimensional structure of the solar wind During solar activity minimum the heliosphere is dominated by the fast solar wind emanating from the polar coronal holes The slow solar wind of the streamer belts is restricted to a limited region of about 25° around the heliographic equator. Inside the coronal hole streams the solar wind is remarkably stable and homogeneous on a larger scale Neither the solar wind speed, nor the freezing-in temperatures and FIP effect show any dependence on latitude or time. On smaller scales, however, the fast solar wind from the coronal holes exhibits distinct quasi-periodic low frequency fluctuations The most prominent fluctuations have an oscillation period of about 2 to 4 days. A second periodic structure is resolvable at about 400 min. Associating them with spatial structures on the Sun would yield angular sizes of several 10° for the 2 to 4 day structure and about 4° for the 400-min structure. The angular size of the 400-min structure and specifically an observed radial dependence fit well to spatial structures previously observed with Helios within 1 AU. Those were interpreted as remnants of coronal fine structures (supergranulations).

THE SILICON AND OXYGEN ABUNDANCE IN THE SOLAR WIND MEASURED WITH CELIAS/MTOF

P. Wurz, R. Kallenbach, P. Bochsler, M.A. Aellig and S. Hefti (University of Bern, CH-3012 Bern, Switzerland)
F.M. Ipavich, A.B. Galvin and G. Gloeckler (University of Maryland, College Park, MD 20742, USA)
H. Grünwaldt and M. Hilchenbach (Max-Planck-Institut für Aeronomie, D-37189 Katlenburg-Lindau, Germany)
F. Gliem (Technische Universität Braunschweig, D-38023 Braunschweig, Germ any)
D. Hovestadt (Max-Planck-Institut für Extraterrestrische Physik, D-85740 Garching, Germany)
and the CELIAS collaboration (Sol. Phys. 162 (1995) 441)

The CELIAS instrument onboard the SOHO satellite is designed to study the ionic and elemental composition of the solar wind and of solar energetic particles. The CELIAS instr ument consists of three time-of-flight mass spectrometers. We will present measurements of the elemental abundance of oxygen and silicon solar wind ions. These measurements are performed with the MTOF sens or (Mass Time-of-Flight) with high mass and time resolution. The obtained elemental abundance will be compared with results from previous missions. The new findings arising from the unique time resolution of MTOF will be discussed in detail.

KINETIC THEORY OF THE BULK ELECTRON ENERGIZATION IN SOLAR FLARES

Yu.M.Voitenko (Main Astronomical Observatory, Kyiv, 252650, Ukraine)

Spatially separated coronal HXR and microwave impulsive sources have been discoverved above SXR flare loops during Yohkoh mission. In the framework of magnetic reconnection hypothesis, we develop kinetic theory for bulk electron energization and flare emissions, based on the kinetic plasma model for the just-reconnected magnetic loops (JRLs). Up to half of the flare energy flux may be converted into heat in the JRL's legs via intermediate kinetic Alfven turbulence. In accordance to our model coronal microwave source is due to thermal synchrotron emission from the heated leg(s) of JRL, whereas coronal HXR source is due to nonthermal HXR bremsstrahlung, produced by escaping electrons in the different region of enhanced density at JRL top. Model testing shows a good agreement with observed events.

VARIATIONS OF BAROMETRIC COEFFICIENT OF COSMIC RAYS NUCLEONIC COMPONENT

V. L. Yanchukovsky, G. Y. Philimonov and **V. L. Yanchukovsky** (Institute of Geophysics, University av.,3, Novosibirsk 630090, Russia)

In studies of the modulation effects of cosmic rays by means of the neutron monitors it is necessary to exclude from the observed data the large variations caused by the atmospheric pressure change. In doing so the used barometric coefficient is often taken as constant. It is shown by us that the observed changes of barometric coefficient associated with the different factors can reach rather large values. The consideration of these changes has been made necessary when correcting the observed data on the variations of atmospheric nature. The functional dependences of the barometric coefficient are established for the different factors namely the rigidity of primary cosmic rays, the rigidity of geomagnetic cut-off, the atmospheric pressure.

WHAT CAN WE KNOW ABOUT PROCESSES OF FORMATION AND DYNAMICS OF DIFFERENT TYPES OF SOLAR WIND STREAMS ON THE BASIS OF PROTON AND ALPHA OBSERVATIONS?

Y.I.Yermolaev (Space Research Institute, Russian Academy of Sciences, Profsoyuznaya 84/32, 117810 Moscow, Russia)

Different average values and dependences of helium parameters (relative abundance na/np, alpha and proton velocity difference DV = Va-Vp, and temperature ratio Ta/Tp) on bulk parameters in different types of solar wind streams studied on the basis of the Prognoz 7 selective plasma measurements of alpha-particles and protons allow us to suggest that processes of formation of solar wind streams and their dynamics in the interplanetary space are different. Helium abundance increases with increasing wind velocity in quasi-stationary streams from 1.7 % in the heliospheric current sheet (HCS) up to 4.7 % in the coronal streamers (CS) and 6.6 % in the coronal holes (CH). Maximum value of na/np 10.5 % is observed in coronal mass ejections (CME) and intermediate between HCS and CS value 3.4 % in the shocked plasma. Helium abundance increases with increasing mass flux and density in streams from CHs and decreases in streams from CSs. No evidence has not been obtained that the processes of alpha-particle acceleration differ from each other in streams from CSs and CHs but they differ from the one in the HCS. In contrast to processes of acceleration the processes of alpha-particle heating in streams from CHs and CSs are suggested to differ from each other but they may be the same in streams from CSs and HCS. The value of alpha-particle heating in streams from CHs increases with increasing absolute value of velocity difference of alpha-particles and protons.

HIGHER SOLAR WIND SPEEDS FROM THE SOUTHERN SOLAR MAGNETIC HEMISPHERE

B. Zieger (Geod. and Geophys. Res. Institute, Hungarian Acad. of Sciences, Sopron, Hungary)
K. Mursula (Univ. of Oulu, Dept. of Physical Sciences, FIN-90570 Oulu, Finland)

The annual variation in the heliosphere has been studied recently by several authors. We reanalyze this periodicity using several SW parameters and geomagnetic activity indices measured since early 1960's. We verify that, during these three recent solar cycles, the annual variation is a quasi-periodicity with maximum amplitude around sunspot minima. Most interstingly, the phase of the annual variation changes from cycle to cycle. This implies an asymmetry between the two solar magnetic hemispheres. The southern magnetic hemisphere seems to emit, on an average, a somewhat faster solar wind. This may be due to a systematically larger extension of polar coronal holes from the magnetic south pole of the Sun.

ST6 Solar mass ejections

Convener. Bothmer, V.
Co-Conveners: Foing, B.H.

CORONAL MASS EJECTIONS AS OBSERVED WITH THE UVCS

Ester Antonucci et al. (UVCS/SOHO Team)
Osservatorio Astronomico di Torino, Strada Osservatorio 20, 10025 Pino Torinese, Italy

On June 7 1996, the Ultraviolet Coronagraph Spectrometer (UVCS) onboard SOHO detected the first UV emission from plasma undergoing a coronal mass ejection. The equatorial West limb was scanned by the UV coronagraph 2 hours after a large coronal mass ejection was observed in the field of view of the white light coronagraph (LASCO) of SOHO. For the first time it has been possible to measure both line-of-sight and radial velocities in the coronal mass ejection region. Line-of-sight velocities are measured on the basis of the Doppler shift of the UV lines, and velocities perpendicular to the line-of-sight are measured through Doppler dimming: in particular, the O VI doublet intensity ratio. Large line-of-sight velocities in the H I Ly alpha line characterized the region within 1.5 and 3 solar radii. Plasma motions were observed to have transverse velocities with opposite directions in adjacent regions. The relative velocity between the plasma approaching and moving away from the observer was about 100 km/sec. Radial velocities above 100 km/sec were observed close to 3 solar radii. The UVCS is the result of a collaborative effort between NASA and the Agenzia Spaziale Italiana (ASI), with a Swiss participation. The Scientific program is led by the Principal Investigator Dr. J. Kohl of the Smithsonian Astrophysical Observatory, in collaboration with several Italian scientific institutions coordinated by Prof. G. Noci, University of Florence, Co-Principal Investigator.

POST-CME ENERGY RELEASE IN THE SOLAR CORONA AND SEVERE GEOMAGNETIC STORMS

I.M. Chertok (IZMIRAN, Troitsk, Moscow Region, 142092, Russia)

The prolonged post-eruption (PE) energy release high in the corona appear to be one of the most outstanding phenomena accompanying eruption of a large coronal mass ejection (CME). We have analyzed microwave bursts of solar sources of the largest geomagnetic storms of $\mid D_{st} \mid > 250\ nT$. Most of them do display a clear PE component. Two main varieties of such a component are observed at microwaves: 1) intense (sometimes predominating) gradual burst with peak flux density (S) up to thousands of s.f.u. and time scale (t) from several tens of minutes to 2 hours; 2) sufficiently intense "gradual rise and fall" (GRF) bursts with $S \approx 30-120\ s.f.u.$ and t up to 7–8 hours. Both varieties may either follow an impulsive (primary) energy release component or occur without such a component. Therefore the PE microwave signatures seem to be an useful indicator of the eruption of a large CME from the central part of the disk that appears to be a necessary (but, of course, not sufficient) condition for a severe geomagnetic storms.

STATISTICAL DYNAMICAL SOLAR WIND MODEL AND GEOEFFECTIVE SOLAR WIND STRUCTURES

A. Dmitriev and A. Suvorova (Skobeltsyn Institute of Nuclear Physics, Moscow State University, Vorobjevy Gory, Moscow, 119899,Russia)

NSSDC OMNIWeb data base from 1964 to 1994 was used to study distribution functions of the solar wind (SW) parameters (about 200000 hourly averaged measurements) such as: strength of the interplanetary magnetic field, SW velocity and density, plasma and magnetic pressures and their ratio. Couples between SW parameters were analysed. Distribution and coupling functions of the SW parameter were considered separately for four phase of solar cycle (time intervals of the minimum, increase, decline and maximum of Wolf number). In result we create statistical SW model (SSWM) included the dependence on the solar activity. Using NSSDC OMNIWeb data base (from 1964 to 1994) we create a catalogue of a strong geomagnetic storms (362 events with Dstj-90) and of the solar wind parameter associated with the storms. The geoeffective Solar Mass Ejection (SME) and Corotation Interplanetary Shocks (CIS) were extracted from catalogue and its properties are discussed. The results of comparison and statistical analysis of relationship between geomagnetic index Dst and solar wind parameters associated with different solar wind plasma structures (SME or CIS) are presented. The place of geoeffective solar wind parameter values in the SSWM is defined.

AN INTERPLANETARY VIEW OF CORONAL MASS EJECTIONS

J.T. Gosling (MS D466, Los Alamos National Laboratory, Los Alamos, NM 87545, USA)
D. J. McComas (MS D466, Los Alamos National Laboratory, Los Alamos. NM 87545, USA)

Coronal mass ejections, or CMEs, are transient events in which large amounts of material from the solar atmosphere are ejected into the solar wind. They originate in closed magnetic field regions in the corona where the magnetic field normally is sufficiently strong to constrain the plasma from expanding outward. CMEs play a central role in the long-term evolution of the corona and are the prime link between solar activity and large, transient solar wind and geomagnetic disturbances. Here we provide an overview of CMEs as observed in the solar wind far from the Sun with emphasis on new observational results from Ulysses and numerical simulations.

MASS EJECTIONS, SECTOR BOUNDARIES, AND STREAM INTERFACES

N. U. Crooker (Center for Space Physics, Boston University, Boston, Massachusetts 02215, USA); J. T. Gosling (Los Alamos National Laboratory, Los Alamos, New Mexico 87545, USA); S. W. Kahler (Phillips Laboratory, Geophysics Directorate, Hanscom Air Force Base, Massachusetts 01731, USA)

Mass ejections may be intrinsically related to sector boundaries and stream interfaces. Elementary topological models of the inner heliosphere predict that mass ejections from helmet streamers should form large bubbles in the heliospheric current sheet as they move out into interplanetary space. Consistent with this prediction, about half of previously documented magnetic clouds (mass ejections with flux rope signatures) can be found at sector boundaries. In some of these cases, the field rotation within the cloud clearly carries the polarity change that marks the sector boundary. Bidirectional heat flux signatures in ISEE 3 data indicate that the sizes of mass ejections at sector boundaries are twice as large as the previously documented clouds. These signatures span what appear to be double flux ropes, possibly signaling passage through both the leading portion and trailing leg of a single but kinematically deformed flux rope connected to the Sun at both ends. Further analysis is underway to test whether mass ejections are also related to stream interfaces, which are interplanetary boundaries between fast and slow flow that closely follow sector boundaries at 1 AU. ISEE 3, Ulysses, and Wind data indicate that in many cases interfaces bound the trailing edge of high-density, transient outflow in the streamer belt. The outflow may take the form of either the trailing portion of a mass ejection or of small-scale, high-density transients on open field lines.

CORONAL MASS EJECTION LINKED TO A CORONAL TRANSIENT - NUMERICAL SIMULATION

Cristiana Dumitrache
Astronomical Institute of Rumanian Academy
Str.Cutitul de Argint 5
75212 Bucharest, Romania

Our simulation replay the problem presented by L.G Forbes, E.R Priest (1984, Solar Phys. 94, p.315) but for five solar radius and taken into account the effects of gravitation and radiative losses. Our numerical experiment focus the large scale magnetic reconnections as result of a photospheric emergent magnetic flux and a coronal field overlying the first. The emergence is stoped at the Alfven time 6. Many reconnections take place and a coronal structure 'helmet' -like forms, empts and reforms. During this proccesses a coronal mass ejection is observed.

Ion composition and charge state analysis of Coronal Mass Ejections encountered by Ulysses at different heliographic latitudes

T. Henke, J. Woch, U. Mall, B. Wilken, Max-Planck-Institut für Aeronomie, Katlenburg-Lindau, D-37191 Katlenburg-Lindau, Germany
J. Geiss, International Space Science Institut, CH-3012, Switzerland
G. Gloeckler, University of Maryland, College Park, Maryland, 20742, USA

We investigate well documented Coronal Mass Ejections (CMEs) that travelled past Ulysses at different heliographic latitudes. Of particular interest are the analysis and the comparison of CMEs that were encountered by Ulysses in either the slow or the fast solar wind.
We use the data of the SWICS instrument to determine the abundances and charge states of rare solar wind ions such as carbon, oxygen, silicon, sulphur, and iron. In order to retrieve the CME events in our data we also calculate the speed, the temperature and the density of protons and alpha particles. The relative ion and charge state distributions of the different CMEs are compared among each other and with those of the solar wind before and after the CMEs. On the basis of these comparisons we try to answer two of questions:

1. Are there different types of CMEs that can be distinguished according to their charge state distributions and what can we learn from that about their source regions (specifically, do CMEs observed in the coronal hole stream differ fundamentally from those seen in the slow solar wind)?
2. Can charge state distributions of rare ions be used as another reliable mean to identify CMEs in interplanetary space?

RESULTS FROM THE SOHO/IACG CAMPAIGN TO STUDY MASS EJECTION ONSETS

R A. Harrison (Astrophysics Division, Rutherford Appleton Laboratory, Chilton, Didcot, Oxfordshire OX11 0QX, UK)

We report on multi-instrument and multi-spacecraft observations designed to study solar mass ejection onsets made during three campaigns in autumn 1996 The basic programme involved the Solar and Heliospheric Observatory (SOHO) with spectroscopic devices monitoring potential ejection source regions whilst good coronal coverage above, and good global coverage was ensured. This observing scheme is called JOP 3 - SOHO Joint Observing Programme 3 and it has been incorporated into a wider scheme involving Yohkoh, Ulysses, Polar and other spacecraft in order to coordinate many solar and interplanetary datasets. This multi-spacecraft coordination has come under the Inter Agency Consultative Group banner.

Thus, we have some unprecedented coverage over three extended periods which certainly include some mass ejection activity. Currently initial analysis is underway and the status of this project and its early findings will be reported upon in this session.

The Observations of CMEs from SOHO/LASCO

R.A. Howard, G.E. Brueckner, M.D. Andrews, J.W. Cook, K.P. Dere, M.J. Koomen, C.M. Korendyke, D.J. Michels, J.S. Morrill, J.D. Moses, N.E. Moulton, S.E. Paswaters, N. Rich, D.S. Socker, N.R. Sheeley, O.C. St. Cyr, S. Stelzelberger, D. Wang, Y.-M. Wang, E.O. Hulburt Center for Space Research Naval Research Laboratory Washington, DC 20375 USA
P.L. Lamy, A. Llebaria, M.V. Bout, Laboratoire d'Astronomie Spatiale Marseille, FRANCE
R. Schwenn, Max-Planck-Institut fur Aeronomie Katlenburg-Lindau, GERMANY
G.M. Simnett, D.A. Biesecker, S. Plunkett, S.J. Tappin, Space Research Group, School of Physics and Space Research University of Birmingham Birmingham, UNITED KINGDOM

The LASCO coronagraphs on the SOHO satellite have been observing the solar corona routinely from 1.1 to 32 solar radii. The coronal mass ejection (CME) phenomena is a frequent event even during the minimum phase of the current solar cycle. A CME is generally observed to occur every two or three days; a definitive determination of the occurrence rate is underway. The increased field of view of the LASCO compared to previous coronagraphs has enabled a better determination of the velocity profile. We find that acceleration is a usually present. Another difference from previous measurements is the frequent observation of disconnection. The properties of CMEs observed by LASCO will be discussed.

ELECTRON SIGNATURES OF INTERPLANETARY PLASMA CLOUDS BETWEEN 0.3 AND 1 AU

Kevin Ivory and Rainer Schwenn (Max-Planck-Institut für Aeronomie, Postfach 20, D-37189 Katlenburg-Lindau, Germany)

Solar mass ejections observed by coronagraphs can often be detected as interplanetary plasma clouds in the solar wind. Magnetic field and plasma solar wind data obtained by the two Helios spacecraft between 0.3 and 1 AU were systematically analyzed for the occurrence of bi-directionally streaming halo electrons. Most often these events are found in conjunction with shock associated magnetic clouds, indicating a closed magnetic field topology. Surprisingly, some magnetic clouds do not show counterstreaming electron events. Implications for the topology of interplanetary plasma clouds are discussed.

CHARGE COMPOSITION IN SOLAR ENERGETIC PARTICLE EVENTS AS OBSERVED WITH SO HO/CELIAS AT 1 AU

B. Klecker, A. Bogdanov, H. Kucharek and D. Hovestadt (Max-Planck-Institut für extraterrestrische Physik, D 85740 Garching, Germany)
M. Hilchenbach and H. Grünwaldt (Max-Planck-Institut für Aeronomie, D-37189 Katlenburg-Lindau, Germany)
R. Kallenbach and P. Bochsler (University of Bern, Sidlerstr. 5, CH-3012 Bern, Switzerland)
F. Gliem (Tech. University Braunschweig, D-38106 Braunschweig, Germany)
F.M.Ipavich (University of Maryland,College Park, MD 20742 MD, USA)

Charge composition measurements have been reported so far for solar wind energie s and for energies larger than a few hundred keV/n. With advanced instrumentation on several spacecraft this gap is now being closed. Onboard SOHO, the time-of-fl ight mass spectrometers STOF and HSTOF of the CELIAS experiment cover this intermedia te energy range. The instruments determine the mass, energy and charge (charge upper limit in HSTOF) of each particle from 35 keV/q up to 700 keV/q (STOF). We report on charge composition measurements obtained during the first yea r of the SOHO mission for several impulsive and coronal mass ejection (CME) related solar energetic particle events.

NON-EQUILIBRIUM OF MAGNETIC FLUX TUBES EMERGING INTO THE SOLAR CORONA

V. D. Kuznetsov (Institute of Terrestrial Magnetism, Ionosphere and Radiowave Propagation, Russian Academy of Science, 142092 Troitsk, Moscow Region, Russia)
A.W.Hood Department of Mathematical and Computational Sciences, University of St Andrews, KY16 9SS, UK.

The lack of equilibrium of twisted magnetic tubes emerging from the photosphere into the corona is considered. Under the assumption of isothermal tube (i.e. the tube equilibrium with the surrounding plasma) with the mass and flux conservation, it is shown that a sufficinently rapid temperature increase through the transition zone may lead to the loss of magnetohydrostatic equilibrium of the emerging flux tube. It is due to the enhanced plasma pressure inside the tube which can't be equalized by the pressure of the surrounding coronal plasma and twisted magnetic field in the tube. The non-equilibrium leads to a rapid expansion and upward motion of the tube to search for a new equilibrium state in more and more rarefied layers of the corona. Expansion of the tube is accompanied by an increasing twist of the magnetic field. As a result, the twist exceeds the threshold for the onset of the kink instability and an explosive release of magnetic energy takes place. The proposed model considers in a self-consistent manner the problem of mass delivery into the corona and the onset of eruptive instability, the problem of magnetic energy release and allows us to describe the origin of the most powerful eruptive phenomena, such as coronal mass ejection.

REMOTE RADIO TRACKING OF INTERPLANETARY CMEs FROM ULYSSES

M. J. Reiner (Hughes STX, Lanham, MD, USA)
J. Fainberg and R. G. Stone (NASA/GSFC, Greenbelt, MD)

Metric type II radio bursts provide a possible signature of the launch of a CME from the sun. Interplanetary (IP) shocks associated with some of the fastest CMEs can generate type II radio emissions at kilometric wavelengths. These latter observations are significant because they provide a means of remotely tracking CMEs through IP space. We show examples of how the Ulysses observations of IP type II radio emissions observed at very low frequencies (20 - 50 kHz) have been used to track CMEs. To do this, we made use of the fact that the IP density falls off as $1/r^2$ and we plotted the observed radio intensity versus 1/frequency and time. On these plots, the frequency drifting type II emission is organized along straight lines. These lines can be extrapolated backwards in time to provide the origin time at the sun and forward in time to predict when the CME may encounter the spacecraft (or Earth). For the case when in situ observations are also made, these data provide clues as to whether the radio emission is at the fundamental or harmonic of the plasma frequency and whether it occurs upstream or downstream of the IP shocks.

MAGNETIC CLOUD ON OCTOBER 18-20,1995, ITS INTEPRETATION AS A FORCE-FREE TOROID WITH CONSTANT ALPHA.

E.P.Romashets (Institute of Terrestrial Magnetism, Ionosphere, and Radio Wave Propagation, Troitsk, Moscow Region, 142092 Russia)

The idea that an isolated force-free magnetic structures can exist in the interplanetary space will be discussed in connection with the cloud observed by Wind on October 18-20, 1995. We interpret this cloud as a toroidal force-free object, which has no common field lines with the Sun. All the parameters of the cloud will be presented: large and small radii, alpha, and also its orientation in the space.

TO THE PROBLEM OF RELATIONSHIP BETWEEN SOLAR FLARES AND CORONAL MASS EJECTIONS

A.I. Verneta

Abstract. Combination of SMM data with Mauna Loa and GOES measurements show significant relationships between coronal mass ejections (CMEs) and solar flares, or, more precisely, long decay (duration) X-ray events (LDEs). This relationship is not understood in all its details. Although mass ejections are considered as a more probable candidate for the role of a driver, there is a problem, namely, which of these two phenomena is cause and which is consequence. To understand this, one traditionally compares start times of CMEs and LDEs. We show that the study of the correlation between XUV line broadening and the origin of CME acceleration gives additional possibilities to solve this problem. In the EUV emission, such investigations might possibly be carried out in the framework of the SOHO program. In the soft X-ray - SMM and Yohkoh data are convenient, albeit not for the same event.

CORONAL TRANSIENT DYNAMICS

I. S. Veselovsky and A. N. Zhukov (Institute of Nuclear Physics, Moscow State University, Moscow, Russia, 119899)

Driving forces (electromagnetic tensions, thermal gas pressure, viscous stresses, gravity force) are estimated together with inertia terms when the mass ejection develops near the heliospheric current wedge position in the solar corona.
Several dimensionless parameters are important to describe the scaling between different terms in dissipative energy and momentum equations. For example, the parameter Ve represents the ratio between the plasma kinetic energy and the electromagnetic output of the event. The dimensionless number Ve delimits flare-like (Ve $<$ 1), intermediate (Ve $\sim$ 1) and CME-like (Ve $>$ 1) energy releases. The Strouhal number S delimits quasistationary (S $>$ 1) and nonstationary (S $<$ 1) processes. The coronal streamer reappears after the CME passage during a characteristic transient plasma time. Hence S $\sim$ 1, and the corresponding regime is the intermediate one. Other examples are indicated of the scaling approach.
A better understanding of CME origins and dominant mechanisms needs measurements of main physical quantities (density, velocity vector, temperature, magnetic field vector etc.) in the formation region using future remote sensing methods.

MAGNETIC HELICITY AND CORONAL MASS EJECTIONS

D. M. Rust (Johns Hopkins University Applied Physics Laboratory, Johns Hopkins Road, Laurel, MD 20723 USA)

There is substantial evidence that coronal mass ejections are the consequence of MHD helicial kink instabilities. This evidence and clues to the build-up of ma gnetic helicity in coronal structures will be reviewed. Each CME can be viewed as the expulsio n from the corona of a calculable amount of magnetic helicity, and the calculati on depends most on the scale of the erupting coronal feature. Since magnetic he licity is conserved in the corona, even in flux rope reconnections and eruptions due to instabi lities, determination of the latitudinal and temporal distribution of the underl ying sources of helicity is obviously important to predicting the distribution a nd frequency of CMEs. While the observational tools to do this don't exist yet, they could be built in the near future. I will offer some suggestions for ways that we can fo llow the transfer of helicity into the corona and its gradual accumulation in de nse filaments and coronal streamers.

CME GEOMETRY

I. S. Veselovsky (Institute of Nuclear Physics, Moscow State University, Moscow, Russia, 119899)

Visual shapes of CMEs differ from case to case in dependence on numerous factors which are poorly known at present. The working hypothesis of the inhomogeneous and asymmetric compressed plasma region adjacent to the expanding and propagating low beta magnetic region in the ambient flowing plasma is used. Turbulent motions make the visual shapes more or less disordered.
The two street system of partial poloidal vortices forming a quadrupole velocity and magnetic field perturbation pattern should appear due to the shear motion and the viscous interaction between the transient and the ambient flow in the corona.
The topological charge of the vortex system depends on the situation and mainly on the velocity differnce betweeen the CME and the ambient flow in the solar wind formation region. The rotation sign of this system is opposite for slow and fast CMEs. It is equal to zero when CME convects with the ambient flow velocity. SOHO/LASCO observations allow to test these predictions.
The problem of the 3D geometry of quasistationary and transient coronal structures may be solved using simultaneous spacecraft tomography observations.

ST7 Solar and heliospheric physics beyond 2000

Convener: Foing, B.H
Co-Convener: Marsden, R.G.

RA: THE SUN FOR SCIENCE AND HUMANITY

Ball, A.J. (Unit for Space Sciences and Astrophysics, University of Kent, Canterbury, U.K.), Tajmar, M. (Technical University of Vienna, Austria), Reinprecht, W. (Technical University of Graz, Austria) and the Ra Project Team of the International Space University 1996 Summer Session

At the 1996 Summer Session of the International Space University, held in Vienna, 53 space professionals from 18 countries addressed the world's future programme of solar-terrestrial exploration and applications. Their mandate was, through an international perspective, to explore and document strategies which will increase our understanding of the Sun and its effects and help us apply solar knowledge for the benefit of mankind. The changed global political, economic and technological environment within which space activities take place has created both obstacles and opportunities for solar exploration and applications. The economic risks of insufficient knowledge of solar phenomena are greater now than ever before, for both terrestrial technologies and space-based systems. The blurring of the line between basic and applied sciences and the movement towards interdisciplinary science missions has created a favourable climate for joint science and applications endeavours. The Ra report is a call to action. We present an international Strategic Framework, containing programmes for the Near-, Mid-and Far-Term. It integrates solar science and applications, capitalises on global resources and talents and harmonises with the political and economic environment. We recommend the immediate establishment of a Working Group for International Solar Exploration and Applications. This would ensure the implementation of a Strategic Framework, synchronise efforts in different countries, facilitate the interaction between science and applications and help combine the output into products useful on a global scale.

The Solar Terrestrial Relations Observatory (STEREO)

V. Bothmer, L. Culhane, J.M. Davila, J. Davis, S. Keil, P. Liewer, B. Mauk, V. Pizzo, D.M. Rust, D. Socker

The next great advance in solar-terrestrial physics will require a view of the Sun-Earth connection from an entirely new perspective. For these purposes we have proposed the Solar Terrestrial Relations Observatory (STEREO) as a new international space mission. The STEREO concept was developed by scientists from Europe and the US at a workshop held at NOAA Space Environment Lab., USA, in August 96 and is currently developed as part of NASA's strategic "roadmap" program for Space Sciences for the first two decades of the next millennium. A solar stereo mission is also considered as a future space mission in ESA's Horizon 2000 program. The STEREO mission consists of four individual spacecraft with the following simultaneous orbits: 2 S/C located at 60 degrees off the Earth-Sun line at 1 AU, one S/C in a 1 AU North-South trajectory tilted from the ecliptic plane and one Earth-orbiting S/C. We present an overview on the scientific objectives of STEREO, the proposed S/C payloads, the required technology developments and the status of the mission planning in the US and Europe.

BEYOND 2000: FORWARD - TO HELIOPAUSE AND STARS

A.M. Chechelnitsky, Laboratory of Theoretical Physics, Joint Institute for Nuclear Reseaech, 141980 Dubna,Moscow Region, Russia

In accordance with the Wave Universe conception and megawave astrodynamics we show that the genesis of well-known in astrogeophysics and Global Change observational rhythms, its commensurability, "symphony" determine by the wave structure of the Solar system and existence of large length and great period waves in the cosmic plasma. In the present work we propose a principally new method to determine the heliopause localization in the Solar system (analized as wave dynamic system - WDS) by using the Fine Structure Constant (FSC). There are theoretical reason to expect, that Heliopause may be found at the distance a=90.5 AU. It must be expected, that the distance a=90,447 AU will be covered by them at the begining of XXI Century.

LOW ENERGY ANOMALOUS COSMIC RAYS IN THE HELIOSHEATH

A. Czechowski (Space Research Centre, Polish Academy of Sciences, Bartycka 18A, PL 00-716 Warsaw, Poland)
S. Grzedzielski (Service d'Aeronomie du CNRS, B.P. No. 3, F-91371 Verrieres le Buisson, France)

The low energy anomalous cosmic rays (ACR) space distribution beyond the termination shock, determined by the combination of diffusion (mostly along the magnetic field lines) and convection by the plasma flow, reflects the global structure of the heliosheath and, by means of the energetic neutral atoms (ENA) created by the charge exchange of the ACR ions with the interstellar atoms, may be observed indirectly from the vicinity of the Earth. We use simple models to find how the ACR distribution in the heliosheath is affected by the structure of the magnetic field and the shape of the heliospheric tail. The ENA hydrogen and helium fluxes coming from the transcharging of the corresponding ions are estimated.

ACOUSTIC TOMOGRAPHY OF SOLAR CONVECTIVE FLOWS AND STRUCTURES

T.L. Duvall, Jr. (Laboratory for Astronomy and Solar Physics, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA)
A.G. Kosovichev and P.H. Scherrer (W.W. Hansen Experimental Physics Laboratory, Stanford University, CA 94305-4085, USA)

We present a new method for helioseismic diagnostics of the three-dimensional structure of sound speed, magnetic fields and flow velocities in the convection zone by tomographic inversion of the acoustic travel-time data. The data are measurements of the time for acoustic waves to travel between points on the solar surface. The travel time of the waves depends primarily on the local wave speed and on the velocity of flow along the ray paths. The effects of the wave speed structure and of flows can be separated by measuring the travel time of waves propagating in opposite directions along the same ray paths. The effects of solar magnetic fields are measured through the anisotropy of the wave speed. A 3D inversion method based on Fermat's Principle and a regularized least-squares technique is applied to infer the properties of convection and magnetic structures.

The initial results from high-resolution SOHO/MDI data reveal large-scale subsurface structures and flows that are important for understanding the physics of solar activity, differential rotation and large-scale convection. We discuss the diagnostic power and limitations of the new method, and propose it to detect signatures of the development of active regions in the Sun's interior using high-resolution data from SOHO and a future space mission.

THE HIREX MISSION: EXPLORING THE SOLAR CORONA FROM 7 KM TO GLOBAL SCALES

L. Golub, J. Bookbinder and E.E DeLuca (Smithsonian Astrophysical Observatory, Cambridge, MA 02138 USA)

The heating, structuring and dynamics of the inner corona occur on spatial scales ranging from < 1 km to > 10^5 km and time scales of seconds to years The inner corona is also the site of solar wind production, solar flares and CME's A new generation of instrumentation and spacecraft technology enables the design and construction of a new mission that can explore uncharted regions in coronal physics by.

1. Spectroscopic imaging of the coronal plasma onto 4096x4096 CCD cameras with pixel sizes of
   (a) 0.01" (7 km), (b) 0 05", (c) 0 5" ;
2. Spectral resolution of < 1 Å from 170-220 Å, covering iron emission lines from Fe IX to Fe XIV and including Fe XXIV, and the O IV and O V oxygen emission lines
3. Photospheric solar magnetic fields at ~1 0 arcsec,
4. Integrated particles and fields instrument package for in situ context measurements

HIREX will orbit at L1 and observe the Sun continuously for 3 years It is baselined as a MIDEX mission HIREX is an international project with European and American Co-Investigators

SIRA-Solar Imaging Radio Array

M. L. Kaiser (NASA/Goddard Space Flight Center, Code 695, Greenbelt, MD, 20771, USA)
R. J. MacDowall and M. J. Reiner (NASA/Goddard Space Flight Center, Code 695, Greenbelt, MD. 20771 USA)

SIRA will be a fleet of 16 micro satellites each equipped with dipole antennas flying in a 10-km formation in solar orbit near Earth. SIRA will do low frequency (<30 MHz) aperture synthesis interferometry of solar type II and type III radio bursts, producing snapshot images of the source regions. The interplanetary type II bursts are usually associated with fast CME shocks. SIRA will be the first attempt ever to image these shock fronts in interplanetary space and track them as they approach Earth. Type III bursts are usually caused by flare-generated supra thermal electrons moving away from the sun on open field lines. Imaging of these type III bursts will allow us to map the coronal density structures between the sun and Earth instantaneously in 2 dimensions and to follow the global orientation of the interplanetary magnetic field. SIRA represents the next logical step in low frequency solar radio astronomy. During quiet times, SIRA will map the cosmic background

A MISSION CONCEPT FOR MEASURING THE LOW DEGREE GRAVITY FIELD OF THE SUN

Maria T. Zuber (Massachusetts Institute of Technology, Cambridge, Massachusetts, 02139, USA)
David E. Smith, James B. Abshire, Bruce C. Bills and David Skillman (NASA Goddard Space Flight Center, Greenbelt, Maryland, 20771. USA)

We are developing a solar orbital mission design that will permit the measurement of the dynamical flattening (J2) of the Sun, the direction of the Sun's rotation axis, and parameters of general relativity associated with its motion about the sun Specifically, our concept would: (1) determine the J2 term accurate to 1%, (2) provide a 10-4% estimate of the relativistic perturbations of the advance of perihelion, and (3) the (average) direction of the Sun's spin axis to approximately 0.1 arcseconds. In addition, should the proposed mission last more than the planned 1-year duration, temporal variations in J2 and the direction of the spin axis should be detectable if they are larger than expected errors. The mission would also have the capability to detect, if they exist, small gravitational deviations from axial symmetry of the Sun's deep interior structure, due to subtle convective or other motions. Our concept involves the launch of a "microspacecraft" into an inclined orbit about the Sun between the orbits of Earth and Mercury that is tracked by laser ranging systems for precise positioning. The spacecraft will have a surface force compensation system that will balance the non-conservative forces of radiation and particle pressure and enable the spacecraft to move in a gravitationally controlled orbit.

ORIGIN OF SOLAR WIND PARTICLE FLUX DENSITY VARIATIONS DURING SOLAR ACTIVITY CYCLE.

V.A. Kovalenko and S.I. Molodykh (Institute of Solar-Terrestrial Physics, 664033, Irkutsk, P.O.Box 4026, Russia)

The model calculations of large-scale heliosphere properties were done for different solar activity cycle periods. This model is based on constancy of the energy and mass fluxes, which penetrates in the corona base. The large-scale configuration of the coronal magnetic fields determines coronal and solar wind energetics. It is discovered, the distribution of the solar magnetic flux open in the interplanetary space has substantial variations during the solar activity cycle, and determines global heliosphere geometry, and, consequently, distribution of solar wind particle flux through heliolatitude. The greater part of the "open" magnetic flux concentrates in large and middle heliolatitudes in the solar activity cycle minimum, whereas the "open" magnetic flux is distributed quasi-homogeneity in the solar activity maximum. Those changes determine observation variations ("in situ" and radio measurements) of the solar wind particle flux during the solar cycle. The greater part of solar wind particle flux is concentrated close to the helioequator in the solar activity minimum, whereas the solar wind particle flux is distributed quasi-homogeneity in the solar activity maximum. It has been found that the decrease of solar wind particle flux density for quasi-stationary high-speed regime was conditioned by increase of the magnetic field magnitude in coronal hole.

HIGH RESOLUTION MEASUREMENTS IN THE SOLAR CORONA

A.Roux,N.Dubouloz(Centre d'etude des Environnements Terrestres et Planetaires,10-12 avenue de l'Europe, 78140, velizy, France), V.Krasnosel'skikh (LPCE/CNRS, Orleans, France), J.C.Vial (IAS,Orsay, France), A.Mangeney, and, N.Vilmer (Obs. Midi Pyrenee, France),J.M.Bosqued,D.Lequeau (CESR/CNES fr), S.Koutchmy (IAP/CNRS,Paris, France), J.P.Thouvenin, J.Y.Prado (CNES, Paris, France)

The outer Solar Corona is one of the last frontiers to be explored. With modern technology it is now possible to conduct an in-situ investigation of the processes that control the formation of the Solar Wind. We report on the outcome of a working group set up to investigate critical scientific and technical issues associated with a mission in the close vicinity of the sun. It is shown that the combination of (1) in situ plasma instruments, (2) high spatial resolution tomographic measurements (on-board the probe), and (3) global coverage from ground based and distant satellites, offers a unique opportunity to identify and understand the processes responsible for the acceleration of the Solar Wind. We will also discuss the possibility of multiple fly-by.

ST8/NP1.4 Nonlinear dynamics in the heliosphere: shocks, solitons and fractals

Convener. Macek, W.M.
Co-Convener: Marsch, E.

STRONG ALFVEN WAVE EVOLUTION ON SOLAR WIND LOCAL DENSITY INHOMOGENEITY

N.A. Barkhatov (Nizhniy State Pedagogical University, 1, Ulyanova St., Nizhniy Novgorod, 603605, Russia)
N.S. Belliustin (Radiphysical Research Institute, 25, Bolshaya Pecherskaya St., Nizhniy Novgorod, 603600, Russia)

The interaction of strong nonlinear Alfven wave with intensive density inhomogeneities in the interplanetary plasma is considered in one-dimensional approach. The Alfven wave form dynamics evolution is investigated in dependence on plasma parameters and inhomogeneity characteristics. Computer simulations show how shock Alfven wave undergoes reversible form changing in high density region - shock wave oscillations decrease here and then restore in more rarefy media. Simulations show also how in result of strong Alfven wave with inhomogeneity interaction dispersed Alfven wave and magnetohydrodynamic disturbances of various types arise. The role of plasma temperature for these processes is investigated, it determines sound speed and changes the interaction between shock Alfven wave and slow magnetic sound waves.

ALFVEN WAVE PARAMETRIC SCATTERING BY SOLAR WIND TURBULENCE

N.A. Barkhatov (Nizhniy State Pedagogical University, 1, Ulyanova St., Nizhniy Novgorod, 603605, Russia)
N.S. Belliustin (Radiphysical Research Institute, 25, Bolshaya Pecherskaya St., Nizhniy Novgorod, 603600, Russia)

Parametric interaction processes of Alfven (A) waves with different kinds of waves on experimental solar wind wave turbulence (T) background were studied within the kinetic equation for plazmons' distribution function in inhomogeneous medium. Quantities of the following A wave effective attenuation were calculated. Interaction process of A wave with fast magnetosound (FMS) wave when A wave merges with FMST background is important for large scale T. Parametric interaction of A wave with slow (SMS) and A waves in presence of FMST and SMST, accordingly, is significant for small scale T. Taking into account the parameter distribution of interplanetary medium along wave transport trajectory it was shown, energetic changes occur with small scale A wave package in upper corona and with large scale A wave package - far from the Sun. During observations these findings make possible the definition of near solar space spherical layers responsible for A waves of specific scales.

MAGNETIC HOLES: MIRROR MODE STRUCTURES VERSUS SLOW MA MODE-TYPE SOLITONS

K. Baumgärtel (Astrophysikalisches Institut Potsdam, D-14473 Potsdam), K. Sauer and E. Dubinin (Max-Planck-Institut für Aeronomie, D-37191 Katlenburg-Lindau)

'Magnetic holes' (MH's) - depressions in the magnetic field magnitude associated with enhancements in kinetic pressure - have been observed in the solar wind, the magnetosheaths of terrestrial planets and in the environments of comets. They are commonly believed to result from the mirror instability which can develop in high beta plasmas with a temperature anisotropy, $T_\perp/T_\parallel > 1$. We introduce an alternative mechanism into the discussion over the physical nature of MH's that is not related to the mirror mode. We suggest an explanation in terms of slow mode-type MHD solitons which propagate with small velocities at large angles to the magnetic field These structures can evolve as stable flow features in the sense of inverse scattering theory, from certain initial conditions in the solar wind plasma, without the need for a temperature anisotropy. This approach allows direct access to the amplitude and the thickness of MH's in a fair agreement with observations.

GENERALIZED EXTENDED SELF-SIMILARITY IN THE SOLAR WIND TURBULENCE

R. Bruno (Istituto di Fisica dello Spazio Interplanetario/CNR, c.p. 27, 00044 Frascati, Italy)
V. Carbone and P. Veltri (Dipartimento di Fisica, Universitá della Calabria, 87030 Roges di Rende (CS), Italy)

Extended Self-Similarity (ESS) has been found to xists in ordinary fully developed turbulence when we plot the q-th order velocity structure function vs. the third-order structure function $S_r^{(q)} \sim [S_r^{(3)}]^{\alpha_q}$. Quite surprisingly the range of scales r where this is verified extends well beyond the usual inertial range, covering the whole range of scales. This behavior exists also in the Solar Wind turbulence and allows us to recover a set of scaling exponents α_q which can be compared with the usual model for intermittency.
However we found that, when we investigate the scaling laws for the magnetic structure functions, in some cases the ESS fails and a departure from the scaling is observed. In these cases we found that a generalized form of ESS always exists. On this basis we can introduce a conjecture for the existence of ESS in both the normal and generalized form. This conjecture is based on the presence of localized velocity and magnetic shears which, acting as local sources of turbulence, could introduce a dependence on the scale r of the scaling parameters related to the multifractal model.

SIGN-SINGULAR MEASURES IN THE SOLAR WIND TURBULENCE

V. Carbone (Dipartimento di Fisica, Universitá della Calabria, 87030 Roges di Rende (CS), Italy)
R. Bruno (Istituto di Fisica dello Spazio Interplanetario/CNR, c.p. 27, 00044 Frascati, Italy)

By using *in situ* satellite observations of the magnetic fields, we investigate the apparent random behavior of the magnetic helicity H_m. Our data analysis is based on the introduction of a signed measure related to H_m. This measure can show a singularity related to extreme oscillations in sign, the scaling behavior of cancellations between positive and negative contributions being characterized by a scaling exponent κ. We found that helicity is sign-singular, a property which underlies to the dominance of a single sign of polarization for fluctuations at small scales. We also found a statistical correlation between κ and the bulk Solar Wind speed. We stress that, even if the usual models based on random phases (introduced to describe magnetic fluctuations) are able to reproduce (in a statistical sense) the gross features of H_m, they cannot reproduce the sign singularity. A different model for the magnetic fluctuations is then outlined.

ON ALFVÉN WAVE FILAMENTATION

Stéphanie Champeaux (Observatoire de la Côte d'Azur, BP 4229, 06304 Nice Cedex 4, France)

A mechanism for small-scale generation in magnetically dominated homogeneous space plasmas is proposed, resulting from transverse collapse (filamentation) of weakly nonlinear Alfvén waves. Special attention is devoted to the zero dispersion limit governed by a generalized vector nonlinear Schrödinger equation, for which the focusing is anisotropic, leading to a splitting of the collapsing centers and the formation of complex small-scales structures.
In the non-stationary regime, it is shown that if the emission duration of the wave-packet is short enough, the collapse can be arrested by magnetosonic waves which intensify in the form of sharp acoustic fronts.
Estimate of the energy burned out in the collapses, shows that Alfvén wave filamentation provides an efficient heating mechanism in the solar corona and significantly contributes to the acceleration of the solar wind.

SOLAR ACTIVITY AND SOC

I. Dorotovič (Slovak Central Observatory, 947 01 Hurbanovo, Slovakia),
Z. Vörös (Geomagnetic Observatory, 947 01 Hurbanovo, Slovakia)

Large dynamical systems tend to evolve (self-organize) into a critical state, when a minor perturbation may lead to avalanche-like instability. In such systems relatively quiet periods are followed by periods of increased activity triggered by an instability in a stochastic way (punctuated equilibrium behaviour). Self-Organized Criticality (SOC) has been proposed as an unifying concept describing the dynamics of such systems characterized by response functions obeying power-laws and self-afine geometry.
In this paper we analyse time series of solar activity represented by Wolf' sunspot number and sunspot area using the concepts of SOC. We transform the original time series on the basis of accumulated activity curves and punctuated equilibrium criteria. Then we show that the transformed time series exhibit clearly all the periodicities of solar activity with no impressions of time or frequency domain filtering techmiques.

NONLINEAR DYNAMICS OF PRECURSOR WAVES OBSERVED UPSTREAM THE EARTH'S BOW SHOCK

T. Dudok de Wit (Centre de Physique Théorique, CNRS and Université de Provence, Marseille, France)
V.V. Krasnosel'skikh (Laboratoire de Physique et Chimie de l'Environnement, CNRS, Orléans, France)

Many experiments have reported the existence of discrete and highly polarized wave packets at the leading edge of collisionless shocks. It has been conjectured that these wavetrains do not result from a plasma instability but rather constitute an inherent part of the shock dynamics itself. Yet, attempts to experimentally identify their leading generation mechanism haven't been successful so far.
Motivated by this problem, we have carried out a detailed analysis of magnetic field data gathered by the AMPTE spacecraft upstream the Earth's quasiparallel bow shock. By extracting the wavefield dispersion relation and the spectral energy transfer rate that characterizes nonlinear wave interactions, new insight has been gained into the nonlinear dynamics of the wavefield. The results show that the precursor waves issue from a competition between dispersion and nonlinearity. A simple model for the creation of these wavetrains from propagating magnetosonic waves of the Riemann type reveals major dynamical characteristics of the underlying physics.

DYNAMICS OF THE MIDDLE- AND SHORTSCALE SOLAR WIND FLUCTUATIONS NEAR THE BOW SHOCK.

P.Eiges, G.Zastenker, N.Astafyeva, M.Nozdrachev and A.Skalsky (Space Research Institute, Profsouznaja st., 84/32, Moscow, 117810, Russia)
J.Safrankova and Z.Nemechek (Charles University, V Holesovicach 23, 180 00, Prague 8, Czech Republic)

Fluctuations of the solar wind ion flux, electric and magnetic fields are studied on the basis of in situ measurements with time resolution from 16 s up to 0.02 s. Wavelet analysis are used by means to investigate the dynamic features of the processes in the different time/space scales. Amplitudes, time scales and dynamics of the parameter fluctuations are compared for three regions: undisturbed solar wind, foreshock ahead of quasiparallel bow shocks and foot/front of quasiperpendicular bow shocks. Middlescale fluctuations of ion flux and magnetic field in the foreshock show a good correlation at the scale from hundreds to tens of second. Comparing of the similar measurements by the two s/c (main sattelite and its subbsatellite) at the distanse about 1000 km alow us to estimate the moving and size of thin solar wind structures. The high frequency (about 1 Hz) ion flux fluctuations significantly increase at the shock front and (in difference to the electric field ones) maintain this high level during many tens of minutes at the downstrem flow.

NON-LINEAR PARTICLE ACCELERATION IN OBLIQUE SHOCKS

D.C. Ellison, Physics Dept., NCSU, Raleigh NC 27695-8202. U.S.A., don_ellison@ncsu.edu, *M.G. Baring* and *F.C. Jones*, LHEA, NASA/GSFC, Greenbelt, MD 20771, USA

We have developed a Monte Carlo technique for self-consistently calculating the hydrodynamic structure of oblique, steady-state shocks, together with the first-order Fermi acceleration process and associated non-thermal particle distributions. Our method overcomes the injection problem faced by analytic descriptions of shock acceleration, and the lack of adequate dynamic range and artificial suppression of cross-field diffusion faced by plasma simulations. We present solutions for plasma quantities and particle distributions upstream and downstream of shocks, illustrating the strong differences observed between non-linear and test-particle cases.

NONLINEAR LOW-FREQUENCY WAVES IN SPACE PLASMAS

M. Gedalin (Ben-Gurion University, Beer-Sheva, 84105, Israel)

Collsisionless shock are generically related to low-frequency nonlinear waves (magnetosonic, Alfven waves, and whistlers). There is a plenty of low-frequency turbulence and probably coherent large-amplitude waves within and in the vicinity of the shock front. Moreover, classical theoretical scenario of the quasiperpendicular fast shock formation describes it as a transformation of a fast magnetosonic soliton into a shock-like structure, when some dissipative mechanisms, like for example, ion reflection, are included. Therefore, knowledge of the nonlinear low-frequency wave features would mean important implications for the shock theory. We review the features of these waves, including dependence on the plasma β and angle of propagation, and the implications for the shock structure. We consider in detail the behavior of the quasistationary one-dimensional nonlinear waves within the framework of hydrodynamical description of the hot plasma. Particular attention is devoted to the propagation of fast magnetosonic waves and existence of soliton-like structures.

STRUCTURE FUNCTION ANALYSIS OF SOLAR WIND TURBULENCE

T. S. Horbury (The Blackett Laboratory, Imperial College. London England)

Recent analyses of Ulysses magnetic field data will be presented. A structure function analysis of small scale fluctuations reveals approximately inertial range turbulence. This turbulence is intermittent, in common with terrestrial turbulence. Comparison with several popular models of intermittent turbulence shows that the p model of Meneveau and Sreenivasan provides the best description of the fluctuations. The reliability of structure function estimates will be discussed in some detail and a simple criterion for the rejection of unreliable results will be presented. In addition, a novel application of wavelet analysis to the study of MHD turbulence. which can provide intermittency information about anisotropic fluctuations, will be discussed.

RELAXATION OF THE SHOCK WAVE-REFLECTED ION BEAM, AND GENERATION OF HOT ELECTRONS

A. E. Indyukov, G. N. Kichigin and N. A. Strokin (Institute of Solar–Terrestrial Physics, P.O.Box 4026, Irkutsk 664033, Russia)

Using results obtained by collisionless shock wave (CSW) experiments on a laboratory device it presents a systematization of relaxation regimes of the ion beam both in the region of main jump of the magnetic field ("ramp") and in the zone of impinging plasma flow. Ahead of the CSW front a reflecting jump of the electrostatic potential was recorded, which was formed by the ion beam reflected by potential hump in the ramp region. An electron acceleration effect in the ion-ion interaction region ahead of the CSW front to energies of about 100 initial temperatures was detected. Hot electrons anomalously rapid propagate from this region across the magnetic field in the form of a localized disturbance. In the neighbourhood of the ion reflection zone in the ramp region, a nonadiabatic heating of electrons to energies about the value of the electrostatic potential within the CSW was detected. Analysing the experimental results authors suppose that the transverse magnetosonic shock wave in a collisionless plasma has the following common structural characteristic: hot electron region - turbulent region, occupied by the reflected ion flux, - diffuson magnetic footing - jumps of plasma parameters and the magnetic field - relaxation region behind the CSW front. Applications of obtained experimental results to solar-terrestrial physics is discussed.

NON-LINEAR ANALYSIS OF TIME-SERIES OF THE MAGNETIC FIELD INTENSITY

P. Kovacs - Eotvos Lorand Geophysical Institute, Hungary
Z. Voros - Geophysical Institute of Slovak Academy of Sciences, Slovakia
A. Juhasz - Eotvos Lorand University, Hungary
L. Hegymegi - Eotvos Lorand Geophysical Institute, Hungary

The behaviour of an open system, like the Earth's magnetosphere, is influenced by the inflow of outer energies. In the case of the magnetosphere, the dissipation of this energy is supposed to take place upon the so-called inhomogeneous cascade model of turbulent processes. The aim of this study is to investigate the statistical roperties of the structures of the evolved turbulence field. The analysed data sets are the one-year long minute-mean records of the magnetic field intensity that were collected by different observatories of the Earth. The empirical probability distribution functions, and the power spectra of the time-series will be presented. The inhomogeneous distribution of the turbulent eddies is examined by the aid of the structure functions. We investigate the scaling of these functions in order to prove the fractal or multifractal character of the statistical distribution of the evolved turbulence field.

STOCHASTIZATION OF PHASES IN FOUR-WAVE INTERACTION

B. Lefebvre and V. Krasnossel'skikh (Laboratoire de Physique et Chimie de l'Environnement, 3A av. de la rech erche scientifique, 45071 Orleans, France)
T. Dudok de Wit (Centre de Physique Theorique, Luminy case 907, 13288 Marseille, France)

We consider the one-dimensionnal interaction of three Langmuir waves with a ion- sound wave. Energy input or dissipation is made through linear growth rates or d amping, considered as parameters. We study this system giving a particular atten tion to the pha Numerical simulations of the Zakharov equations showed that the "cascade" predic ted by the weak turbulence theory is often truncated after three or four peaks [e.g. Hanssen et al., J. Geophys. Res., 97, A8,1992].
The three-wave interaction with a mistmatch in resonance conditions may lead to stochastization of phases, but is unable to saturate the instability at exact re sonance [e.g. Wersinger et al., Phys Fluids 23(6), 1980].
The four-wave model c an describe a c

NUMERICAL SIMULATION OF THE STRONG TURBULENCE ORIGINATED BY AN ELECTRON FLUX IN SPACE PLASMA

G.V.Lizunov, E.V.Podladchikova (Kiev Shevchenko University, Physics Dept., pr. Glushkova, 6, Kiev, 252022, Ukraine)

In many cases charged particle fluxes interact strongly with space plasma causing plasma turbulence. Such interactions are noticed in auroral ionosphere, in shock region, during active plasma experiments, etc. We present the results of 1D computer simulation of nonlinear dynamics of electron beam injected into the half-space with electron-ion plasma. The following consequence of events has been observed: Langmuir waves build up due to the two-stream instability, effect of plasma waves accumulation, trapping of the bulk of ambient electrons by generated wave, collisionless plasma heating due to the mixing of particles in phase space, appearance of the ion density irregularities and Langmuir solitons (modulation instability), and the trigger character of beam-plasma interaction. Results of computer experiment we compare with existing theories as well as observational data.

FRACTAL ANALYSIS OF THE SOLAR WIND

Wiesław M. Macek (Space Research Centre, Polish Academy of Sciences, Bartycka 18 A, 00-716 Warszawa, Poland)

There is mounting evidence from recent data analysis that the turbulence in the solar wind is not fully described by Fourier analysis. Further, the probability distributions for the slow solar wind are clearly non-Gaussian at small scales. Random data usually give rise to a Gaussian probability distribution function of measured parameters. For chaotic data the distribution is likely to be a fractal, even though the normal distribution is not excluded. The results of research on scaling and fractal properties of the solar wind fluctuations will be considered. In particular, we analyse time series of plasma parameters of low-speed streams measured by the Helios spacecraft in the inner heliosphere, which is a region of space dominated by the solar wind flow. The application of time-series fractal analysis and structure functions, which are new nonlinear methods for data analysis, is especially relevant for studying the question of whether the irregular behaviour of the solar wind flow results from intrinsic nonlinear chaotic dynamics or from external forces.

NONLINEAR DYNAMICS OF COHERENT AND SOLITARY ELECTROSTATIC WAVE STRUCTURES WITH APPLICATIONS TO SOLAR WIND OBSERVATIONS

A. Mangeney and C. Lacombe (DESPA, Observatoire de Paris, 92195 Meudon, France)
V.I. Sotnikov (Institute of Atmospheric Physics, Academy of Science of the Czech Republic, Bocni-II, Prague 4, CZ)

Nonlinear solitary and coherent electrostatic wave structures were discovered recently by the Wind spacecraft near the Lagrangian point (see the abstract by *Salem et al.*). In order to examine possible nonlinear mechanisms which can lead to the appearence of such structures in the solar wind plasma, with hot and cold electron populations and a proton temperature comparable with the cold electron temperature, an analytical analysis and kinetic Vlasov simulations were carried out. The results indicate that under certain conditions the development in the nonlinear behaviour of the finite amplitude electron acoustic oscillations can reproduce wave forms observed during the experiment on board of the Wind spacecraft. Necessary conditions for solar wind plasma parameters to allow such nonlinear structures to develop will be presented as well.

STRUCTURAL INSTABILITY OF DISCONTINUOUS MAGNETOHYDRODYNAMIC FLOWS

S.A. Markovskii (Sternberg Astronomical Institute, Moscow State University, Moscow 119899, Russia)

In the recent years the interest to structural instability of discontinuous flows resumed due to the new satellite observations of the heliosphere. We consider this phenomenon from the view point of the principle of evolutionarity in the framework of magnetohydrodynamics. For a non-evolutionary discontinuity the problem of time evolution of its small perturbation does not have a unique solution, therefore it cannot exist as a stationary configuration. At the present time the nonlinear evolution of such discontinuities is a matter of debate. We show that the governing factor of their behavior is that a non-evolutionary configuration can be represented as a set of more than one discontinuity. It is thus structurally unstable and must disintegrate into evolutionary discontinuities or transform to some more general non-steady flow. We generalize the principle of evolutionarity to inhomogeneous and dissipative flows. As a result we obtain new criteria of structural instability for quasi-one-dimensional configurations, such as a reconnecting current sheet, as well as for the discontinuities in the profile of inviscid shock waves. This allows us to explain the unclear features of discontinuous magnetohydrodynamic flows observed in numerical experiments.

NONLINEAR STAGE OF ALFVÉN WAVE PHASE MIXING

V.M. Nakariakov and B. Roberts (School of Math. and Comp. Sciences, University of St Andrews, St Andrews, Fife KY16 9SS, Scotland)
K. Murawski (WIBiS, Politechnic of Lublin, ul. Nadbystrzycka 40, 20-618 Lublin, Poland)

The nonlinear coupling of Alfvén and fast magnetoacoustic waves in a magnetised compressible plasma with transversal inhomogeneity of plasma density is considered analytically and numerically. The inhomogeneity leads to the generation of transversal gradients of magnetic pressure due to phase mixing of the Alfvén waves. These gradients excite fast magnetoacoustic waves, a part of which propagates across the magnetic field and moves energy from the regions with the sharpest gradients in the density. Due to refraction, the fast waves shift to regions with low Alfvén speed. Oblique propagating fast magnetoacoustic waves may be subject to effective dissipation leading to plasma heating which is spread around the region of the density inhomogeneity. Moreover, the fast waves contain perturbations of plasma density and can be a source of particle acceleration. The efficiency of the nonlinear interaction of the Alfvén and fast waves depends upon the strength of the inhomogeneity resulting in secular temporal and/or spatial growth far from the source of Alfvén waves.
The proposed mechanism offers an explanation for the observed appearance of magnetoacoustic fluctuations in the solar wind far from the Sun, together with a decay in Alfvénicity. The mechanism is also important for solar coronal heating.

SOLITONS IN BI-ION PLASMAS

G. Mann, P. Hackenberg (Astrophysikalisches Institut Potsdam, Telegrafenberg A31, D-14473 Potsdam, Germany), and
E. Marsch (Max-Planck-Institut für Aeronomie, D-37191 Katlenburg-Lindau, Germany)

In space plasmas heavy minor ions frequently occur in the solar wind, in the vicinity of comets, and in front of travelling interplanetary shocks and planetary bow shocks. The appearance of minor ions is associated with low frequency plasma waves as demonstrated by extraterrestrial in-situ measurements. The plasma waves are treated by means of multi-fluid equations. A perturbation theory is developed for a left-hand circularly polarized, low frequency plasma wave. Taking the first nonlinear terms into account, the multi-fluid equations are reduced to a nonlinear Schrödinger type equation. The derived solitons are only appearing in a magnetized bi-ion plasma. The properties of these solitons are discussed for plasma parameters usually found in the solar wind. An enhanced abundance of helium ions is observed within these solitons.

POLYSPECTRAL ANALYSIS OF SLAMS EVENTS OBSERVED AT THE EARTH'S QUASI PARALLEL BOW SHOCK

A.Masson (Laboratoire de Physique et Chimie de l'Environnement, CNRS,45071 Orleans cedex 02, France)
F.Lefeuvre, V.V. Krasnosel'skikh (LPCE/CNRS, 45071 Orléans cedex 02, France)
M.Dunlop (Imperial College, SW1 London, England)

Statistics of order 3 (bicoherence) and 4 (tricoherence) are used to analyse SLAMS (Short Large Amplitude Magnetic Structure) events, observed by the AMPTE-UKS spacecraft at the Earth's quasi-parallel bow shock. Two different treatments are performed, one on the full time series, the other on time intervals on which SLAMS have been identified. This identification is made both as in Schwartz et al. (J.Geophys. Res., 97, 4209, 1992) and from estimated values of the non-mormalized skewness. Strong peaks in the tricoherence function point out the presence of four wave non-linear interactions. A residual is seen on the bicoherence Comparison of non-linear interaction with directly calculated growth rate and damping from bi-satellite data is carried out. Interpretation in terms of an inverse parametric decay from the SLAMS frequency towards the ion gyrofrequency is proposed.

EXTRACTING NONLINEAR DYNAMICS FROM THE SOLAR WIND

Lidia Obojska and Wieslaw M. Macek (Space Research Centre, Polish Academy of Sciences, Bartycka 18 A, 00-716 Warszawa, Poland)

We analyze a time series of velocities of low-speed streams measured by the Helios spacecraft in the inner heliosphere. We apply the method of singular value decomposition to represent the data in terms of a complete set of orthogonal functions. By neglecting some eigenvalues of the trajectory matrix we remove a substantial amount of noise. We show that, a simple nonlinear function of these basic functions is sufficient to reproduce the nonlinear dynamics of the system. Some geometric invariants of the dynamical system, as fractal dimension and entropy, are also calculated. These results provide evidence that the inner heliosphere is likely to be a nonlinear chaotic system.

SOLITARY AND COHERENT ELECTROSTATIC WAVES IN THE SOLAR WIND

C. Salem, A. Mangeney, C. Lacombe and J.L. Bougeret (DESPA, Observatoire de Paris, 92195 Meudon, France)
P.J. Kellogg (School of Physics and Astronomy, University of Minnesota, Minneapolis, MN 55455, USA)
J.M. Bosqued (CESR, 9 avenue du Colonel Roche, 31029 Toulouse, France)

The Time Domain Sampler experiment, on board the WIND spacecraft, measures electrostatic waveforms with a very good time resolution (up to 10 μs). We study the waves detected in the solar wind near the Lagrange point : the waveforms appear as solitary spikes (lasting less than 1 ms) or coherent wave packets (1 to 6 kHz). Some waves are also observed at the electron plasma frequency (around 20 to 30 kHz). The occurrence of the electrostatic waves is studied as a function of the solar wind velocity, of the temperature ratio T_p/T_e, and of the shape of the electron and proton distribution functions. We discuss the results of simulations, using a 2D Vlasov code, of the electron acoustic instability.

TURBULENCE DOWNSTREAM OF QUASI-PARALLEL COLLISIONLESS SHOCKS: SIMULATIONS

M. Scholer (Max-Planck-Institut f. extraterrestrische Physik, 85740 Garching, Germany)

We will discuss one-dimensional hybrid simulations (massless electrons, macro ions) of almost parallel collisionless shocks over a wide range of Mach numbers. One of the key questions is whether downstream convected upstream waves or waves locally generated at the interface of the incoming solar wind and the partially thermalized plasma are the main source of the downstream turbulence. In the medium, supercritical Mach number regime the small-wavelength interface waves are damped in a transition region and contribute to downstream dissipation. These waves are right-hand polarized and propagate in the downstream rest frame toward the shock. In an Alfvén Mach number regime around $M_A \sim 8$ we find behind the shock ramp right-hand polarized waves with both helicities. This is interpreted in terms of both the ion/ion resonant and the ion/ion right-hand nonresonant instability occuring in the shock transition region. In this Mach number regime the shock produced waves have larger wavelengths and are less strongly damped. It is suggested that they are subject to a parametric decay instability, resulting in an inverse cascade of short-wavelength waves to longer ones further downstream. In the very high Mach number regime damping as well as decay of the shock produced waves is slow compared to the transit time from the shock to the magnetopause. The shock generated waves are then expected to be the dominant source of the downstream turbulence.

IS THE SUNSPOT CYCLE AN INTEGRAL CHAOTIC ATTRACTOR OF A SYSTEM UNDER GLOBAL CONSTRAINTS

G. Sonnemann (Institut fur Atmospharenphysik, 18225 Kuhlungsborn, Germany)

A non-linear dissipative reaction-diffusion system with characteristic internal cumulative feedbacks and terms of global coupling (i.e. a partial integro-differential equation system) has been investigated on the basis of a 3d-model. Such systems possess particle solutions - sometimes called autosolitons. Enhancing a (control)parameter of the system driving term the particle creates nearly a limit cycle of the integral of a definite system variable after a Hopf bifurcation. There arise a spinning internal dynamics. The frequency of the limit cycle is twice as much as the spin frequency. Further increase of the control parameter leads to a second bifurcation creating an integral chaotic attractor. The chaotic character of the attractor has been proved. The new route into chaos is marked by a modulation of the amplitude of the limit cycle by an incommensurable frequency with increasing amplitude. This amplitude becomes unstable and rises exponentially after the bifurcation.
One of the most surprising outcomes of the chaos research is the universal validity of certain results. Although the system does not model solar processes, the integral chaotic attractor shows striking characteristics of the time behaviour of the sunspot number - an integral quantity, too. The typical characteristics of the sunspot cycles will be compared with the model calculations. Assuming the sunspot cycles obey such a chaotic behaviour, some important conclusions can be derived. There are no regular periods but only two quasi regular periods of a statistical mean duration. A long-term prediction of the solar activity is impossible. A depletion of the solar activity, such as the Maunder-minimum, occurs in irregular intervals. There could have happened two catastrophic bifurcations in the history of the sun.

KINETIC DESCRIPTION OF DUSTY PLASMA SOLITONS

A.J.Turski (Institute of Fundamental Technology Research - PAS , ul Swiętokrzyska 21,PL 00-049, POLAND)

Dust is a common component of many space plasmas and waves in dusty plasmas have recently been considered when the dust grains are charged. Dusty plasma physics is of great importance with a number of application. Recently, attention has been focused on planetary rings in which heavy micron size dust grains are charged to high degree. In particular, in the F-ring of Saturn there is an extreme anomalous situation where the number density of free electrons is much smaller than the number density of ions. This could happen because the charged dust grain collect electrons from the background medium and the number density of free electrons is anomalously small. It is found that dusty plasmas of Space satisfy assumptions leading to collisionless Vlasov plasmas. Vlasov-Poisson/Ampere equations for multi-component plasmas are considered. Assuming suitable equilibrium distributions for cold and hot charged particle/grain components, due to negligence of wave-particle interactions and assuming traveling wave far field solutions, fully nonlinear ODE is gained for SAGDEEV potential. Examples of negative solitary potentials associated with fully nonlinear dust-acoustic waves are computed.

ON SYNERGISM OF ALFVÉN FIELD LINE RESONANCES

Z. Vörös (Geomagnetic Observatory, 947 01 Hurbanovo, Slovakia).
A. Kormendi (Geophysical Observatory, 8237 Tihany, Hungary).
A.W. Green (U.S. Geological Survey, Denver, MS 968, Box 25046, CO 80225-0046, USA).
A. De Santis (Inst. Nazionale di Geofisica, Vigna Murata 605, I-00143 Roma, Italy).
P. Kovács (Eötvös Loránd Geophys. Inst., P.O.B.35, 1440 Budapest, Hungary)

Research on the temporal and spatial structure of wave processes in the magnetosphere has been carried out for a long time. Recently, the fundamental role of Alfvén field line resonances in the formation of Pc 3 - 5 pulsation fields at high and middle lattitudes has been recognized. It is believed that the frequencies of some of these pulsations are controlled by the solar wind while the frequencies of others are controlled be resonances (eigenmodes) of individual earth field lines. Recent work has shown that cross phase measurements may be used to identify eigenmodes properly.
The main objective of this paper is to provide experimental evidence of nonlinear character of the evolution of geomagnetic eigenmodes and their interaction with the background plasma under varying field conditions. In order to distinguish between deterministic versus stochastic eigenmode processes several nonlinear techniques such as dimension and Lyapunov exponent estimation, nonlinear prediction and multifractal techniques will be considered in the paper.

The influence of the cosmic rays and LISM neutrals on the solar wind termination shock

Joanna Ziemkiewicz, Marek Banaszkiewicz Space Research Centre, ul. Bartycka 18a, 00716 Warsaw, Poland

The model of the nonpolytropic solar wind in the presence of galactic (GCR) and anomalous component (ACR) cosmic rays is presented. The interaction of the wind ions with the LISM neutrals is taken into account self-consistently by introducing the appropriate source terms in the flow equations. A spectrum of the possible configuratios of the outer heliosphere arises as a result of numerical integration of the model differential equations. The dependence of the shock radius on the initial (at 1 AU) speed and density of solar wind, on the efficiency of ACR production and on the assumed strength of the interction with neutrals is discussed.

Stability of the dust-acoustic solitons

Joanna Ziemkiewicz, Space Research Centre, ul. Bartycka 18a, 00716 Warsaw, Poland, e-mail: ziemk@cbka.waw.pl

The stability of the nonlinear wave and solitons solutions is examined in a four component plasma consisting of electrons, two distinct positive ion species and negatively charged dust grains. The stability investigation is performed in the small k (long wavelength) approximation. The solitons are found to be highly unstable with respect to the oblique perturbations. The dependence of the instability growth rate on the ratio of dust to plasma density is presented. The results apply to the lower ionosphere of Earth, the ionosphere of Mars in the vicinity of Phobos, as well as to the cvometary tails.

ST9 New approaches to studies of wave-particle interactions in the magnetosphere

Convener: Rycroft, M.J.
Co-Conveners: Eliasson, L.; Horne, R.; Trakhtengerts, V.Y.

THE SHORT PERIODIC VLF MAGNETOSPHERIC EMISSIONS AS A WAVE-PARTICLE INTERACTION RESULT

P.A. Bespalov (Institute of Applied Physics, 46 Ulyanov st., 603600 Nizhny Novgorod, Russia)

In this report, the problem of short periodic VLF emissions with typical periods 2-6 s is studied in more detail. We studed a self-consistent problem of the interaction between electromagnetic VLF emission and electron radiation belts without ordinary simplifications because the electromagnetic pulse duration can be comparable with the variational time of the distribution function. We took into account both the linear dispersion in the nonuniform magnetospheric resonator and the cyclotron amplification variation during the pulse as a result of the wave-particle interaction. If the energetic electron distribution function has appropriate form, the consolidation of emission in packets reduces the dissipation of electromagnetic energy, and these processes can give a gain in energy. Consequently, the effective saturation of dissipation leads to rather short electromagnetic pulses which pass between conjugate ionospheric regions without shape variation. The cause of the excitation of short periodic VLF emissions is connected with the compensation of the dispersion signal transformation and the quasilinear evolution of the cyclotron instability increment as a result of the evolution of the distribution function during the electromagnetic pulse.

NEW MODELS OF WAVE-INDUCED PRECIPITATION OF STORM-TIME RADIATION BELT PARTICLES

A. G. Demekhov (Institute of Applied Physics, 46 Ulyanov st., 603600 Nizhny Novgorod, Russia)

Formation of precipitation zones of energetic charged particles by cyclotron wave-particle interactions during magnetic storms will be discussed. These zones are localized near the contact of the energetic particle drift trajectories with the plasmasphere or detached plasma clouds. We present recent results of the self-consistent theory of wave-particle interactions that can be quantitatively compared with complex experimental data on trapped and precipitated particle fluxes, wave intensity and cold plasma density. In particular, we consider analytical and numerical models taking into account a real source of energetic particles due to their drift into the region of dense cold plasma where the instability develops. Spatial distribution of trapped and precipitated energetic particle fluxes is found; characteristics of temporal precipitation pulsations in auroral zone are investigated. Comparison with particular observations is made to show the validity of the used approach.

THEORY OF SPLIT LANGMUIR PROBE OPERATION FOR WAVES STUDY

F.Doudkin, V.Korepanov (Lviv Centre of Institute of Space Research, Naukova str., 5-A, 290601, Lviv, Ukraine)

Starting from late 60-ties first in USA and then in Europe the attempts are constantly made to develop the sensor for spatial current density fluctuations measurement for waves study. The most suitable instrument for this - split Langmuir probe (SLP) - was already used in rocket and satellite flights, but no exact theory of its operation exists until now. An attempt to develop the theoretical approach to the explanation of peculiarities of SLP operation in tenuous space plasma was made. It is shown that in order to provide current mode of SLP operation it is necessary to fulfil the condition Ri/Re<<1, where Re - own SLP resistance relative to external media, Ri - reference inner resistance of SLP, to which electronic amplifier is connected. The Re dependence from plasma parameters and frequency band is investigated and a set of critical SLP parameters responsible for its transfer function is introduced. The results of mathematical modelling are discussed and factors limiting SLP sensitivity are determined. Also the comparison of an efficiency of the SLP and other device able to measure current density - Rogovsky coil - is made and SLP advantages are shown.

MULTIPOINT OBSERVATIONS OF PERIODIC AND QUASI-PERIODIC ELF/VLF EMISSIONS AT HIGH SOUTHERN LATITUDES

M. J. Engebretson (Technical University of Braunschweig, Braunschweig),
A J Smith (British Antarctic Survey, Cambridge), U. S. Inan (Stanford University, Palo Alto), R. L. Arnoldy (University of New Hampshire, Durham) and H. Fukunishi (Tohoku University, Sendai)

New arrays of Automatic Geophysical Observatories (AGOs) in Antarctica provide the first simultaneous multipoint observations of ELF-VLF emissions using a latitudinal chain of stations at Λ=60°-80°. We find ULF modulations of dayside ELF-VLF waves typically in two frequency bands: 15-60 mHz, and 100-300 mHz, conventionally known as quasi-periodic (QP) and periodic emissions respectively. Surveys of all available 1993 and 1995 data from Halley (Λ=60°) and South Pole (Λ=74°), and from British and U.S. AGOs, spanning a distance of ~ 2000 km, with typical spacing 500 km, show the following typical features: 1) A class of QPs (type I) is closely linked to Pc 3 ULF waves of the same frequency, which is proportional to the magnitude of upstream waves; occurrence is controlled by the IMF cone angle. 3) Periodic emissions are often accompanied by a second class of QPs (type II) and are seldom accompanied by magnetic pulsations. Their frequencies are related by a constant difference, not a constant ratio, and often fall simultaneously during local morning hours. The frequencies of these type II QP events are unrelated to the frequency of (occasionally simultaneous) type I QP events. 4) QP waveforms of both types are coherent (to within the 1-s or 2-s sampling rate) at all stations, but never with simultaneously observed Pc 3 pulsations. We propose a mechanism involving ducting and FACs, whereby periodic emissions stimulate Type II QPs.

SIMPLE MODEL TO STUDY THE WHISTLER-MODE WAVE GROWTH AT THE EQUATORIAL PLA NE OF MAGNETO-SPHERE

N. Erokhin (Space Research Institute, Profsouznaya Str.84/32, 117810 Moscow, Russi a)
D. Nunn (Department of Electronics and Computer Science, University of Southampt on, SO9 5NH Southampton, UK)

The kinetic theory of cyclotron resonance interaction of a ducted whistler-mode wave with energetic electrons near the equatorial plane in the magnetosphere is developed. The simple model taking into account the parabolic inhomogeneity of geomagnetic field and a distribution function of resonant electrons is proposed.
This model is self-consistent and it is directed to study by more rigorous way and to clarify physically the VLF-emission triggering. This work is supported by INT AS (grant 94-2753).

EXACTLY SOLVABLE MODEL OF FAST ELECTRONS AC-CELERATION AND RETARDATION BY FINITE AMPLITUDE LOW-HYBRID WAVE PACKETS

N. Erokhin and L. Mikhailovskaya (Space Research Institute, Profsouznaya Str.84/32, 117810 Moscow, Russi a)
M.J. Rycroft (International Spacc University, Parc d'Innovation, Boulevard Genthier d'Andernach, F-67400 Illkirch, France)

The acceleration-retardation of fast electrons by finite amplitude packet of low-hybrid waves in the magnetosphere is considered both analytically and numerically. The simple exactly solvable model is proposed to study this process . It allows to consider the dependence of acceleration and retardation efficiency on all important parameters (wave amplitude, phase-group velocities difference, the
electron's energy and the wave phase at the point of electron encounter with a wave packet). The results obrained give possibility to write .the relation of incoming electron momentum with outgoing electron one (the scattering matrice) necessary for computer simulation of two-hump distribution function of the reson ant electrons which is observed experimentally. The model proposed is also describe a number of acceleration mechanisms (the acceleration by Fermi mechanism, diffusiv e acceleration one et.al.).

ON THE TIME DELAY BETWEEN PULSATING AURORA AND VLF-CHORUS

I. A. Kornilov, A.A.Lubchich, B.V.Kozelov, E.E.Titova (Polar Geophysical Institute, Apatity, Russia)
J. Manninen, T. Turunen (Geophysical Observatory, Sodankyla, Finland)

During cooperative Finnish-Russian experiments in 1993-95 TV observations of aurora and VLF emissions with synchronous recording on videotape were carried out at the northern Finland (69 N, L=5.9) and Kola Peninsula (Russia, 68 N, L=5.2). TV data on pulsating aurora and accompanied VLF-chorus emissions (12 hours of observations in total) have been analysed, using 2-dimensional autocorrelation and cross-correlation functions representation. On the basis of auto-correlation functions analysis one can conclude that time and amplitude characteristics of VLF chorus have mainly a noise-like nature, though some elements of regularity common with those for auroral pulsations also exist. Auroral pulsations also show the figures of there own internal structure which do not present in the VLF signal data set. Crosscorrelation study demonstrates statistically the existence of some time delay between individual chorus elements and flashers of fast auroral pulsations of about 1-2 sec. (VLF can lead aurora and vise versa). Different types of such a delay have been found and their dependence on geophysical conditions, types of pulsations, local time were investigated. Possibility to use the time delay between VLF emissions and auroral pulsations for localization of the cyclotron wave-particle interaction region is discussed.

FRACTAL ANALYSIS OF PULSATING AURORA AND VLF-CHORUS

B.V.Kozelov, I.A.Kornilov (Polar Geophysical Institute, Apatity, Russia)
J.Manninen, T.Turunen (Geophysical Observatory, Sodankyla, Finland)

Simultaneous measurements of VLF emissions and TV observations of aurora are analyzed by methods of fractal analysis. The data used were obtained during cooperative Russian-Finnish experiments in 1993-95. It was found that the auroral data usually have low-dimensional ($D_c<1$) structure at the high amplitude scales and the VLF emissions mainly tend to white noise features. However, there are localized events when the VLF data have the low-dimensional behavior ($3\geq D_c\geq 2$). During these events for auroral data it has been found increasing of the dimension to $D_c\approx 4$ that is higher than one for correspondent VLF data sets. This relation of aurora and VLF emissions agrees with results obtained in report of [Kornilov *et all.*, this issue]. It was demonstrate that there is a correlation with time delay of about 1-2 s between individual chorus elements and flashers of fast auroral pulsations. However auto-correlation function of the optical data sets also demonstrates the correlation times that absent in the VLF data. The results support the conclusion that during these events the auroral pulsations and VLF chorus are partly driven by the same process in the magnetosphere, but the auroral pulsations have additional non-chaotic degrees of freedom. The results seems to be important to studies of wave-particle interactions in the magnetosphere.

DIFFERENT TYPES OF ELECTRON INJECTIONS IN THE MAGNETOSPHERE AND IMPULSIVE PRECIPITATIONS IN THE MORNING SECTOR

A.A.Lubchich, A.G.Yahnin, E.E.Titova (Polar Geophysical Institute, Apatity, Russia)
R.D.Belian (Los Alamos National Laborartory, Los Alamos, New Mexico, USA)
R.Rasinkangas (University of Oulu, Oulu, Finland)
T.Turunen, J.Manninen (Geophysical Observatory, Sodankyla, Finland)

The dynamics of particle flux and anisotropy after two particle injections seen by the CRRES and geosyncronous LANL satellites has been investigated. For the first injection occurred in the localized part of the night sector the behavior of the energetic electron flux agreed well with that expected from the magnetic drift in the dipole-like field. In agreement with the magnetic drift model, the measured electron anisotropy increased during the drift from the night to the early morning sector. The stabilization of the pitch angle distribution further to the East has been interpreted as a signature of scattering due to cyclotron wave-particle interaction. Indeed, simultaneous observation by EISCAT, which was situated in the morning sector, showed rather strong impulsive precipitation of energetic electrons. Also the VLF emissions were detected on the ground. The second injection in the magnetosphere occupied a very large area, it did not show any significant anisotropy, and produced precipitation of another type. To explain the different precipitation regimes the cyclotron maser theory has been applied, and measured anisotropy has been included as an input parameter. A good coincidence of theory prediction and observations has been found.

ELECTRON WHISTLER MODE WAVE INTERACTION VIA SELF-CONSISTENT 1D PIC SIMULATIONS

S.K.Matsoukis and S.C.Chapman(Space & Astrophysics Group,Warwick Univ.,UK)

The above simulation studies were carried out in order to examine the deviations of self consistent systems from the single particle in prescribed wave field description. Propagation of large scale amplitude whistler mode waves along and across a fixed ambient field has been studied in detail.In parallel propagation the spectrum is dominated by an electron whistler mode wave.The PIC code was tested for several wave amplitudes and it was shown that higher order phase space resonances occur as the wave amplitude increases and the interaction becomes strongly nonlinear ,followed by a complex evolution of the system .The interpretation of the phase space trajectories of the electron population has taken place through application of the delay coordinate technique which allows us to extract the frequency information in the electron trajectories.Study of the delay coordinate plot for large wave amplitude ,shows: i) trapping of large number of particles with characteristic frequencies around the estimated primary trapping resonance frequency corresponding to the wave amplitude ii)a cluster of frequency components around the main frequency not always located at symmetric 'mirror' positions.This indicates the presence of higher order resonances as well as a net shift in time of trapped electron phase-space motion towards a lower trapping frequency.Simulations in oblique propagation allow study of electrostatic and whistler mode waves and the coupling between them.Trapping effects again occur, preliminary results ,however, suggest that strong asymmetry may not appear on the delay coordinate plot.Results from both propagations will be compared and dicussed in detail.

A STUDY OF WAVE-PARTICLE INTERACTION DURING GEOMAGNETIC STORM.

Mineev Yu.V.
Scobeltsyn Institute of Nuclear Physics, Moscow State University.
119899 Vorobjevy Gory, Moscow, Russia

During satellite "Intercosmos-19" based experiment at first time was obtained an opposition movement of the space structure of particles' fluxes (electron with energies Ee=0.04-2.0 MeV) from one side and waves (with frequency 140-15000 Hz) and thermal plasma from another side during main storm phase and recovery phase on height 500-800 km and L=1.2-2.5. This fact lets to obtain the movement velocities of waves and particles v^w and v^p. During the magnetic storm main phase the boundary of energetic electron registration shifts towards high latitudes, whereas the boundary of wave and plasma registration shifts towards lower latitudes. The described phenomenon and also observed reconstruction of waves' and particles' spectra with indexes γ^w and γ^p are used to study wave-particle interaction inside plasmosphere during various storm stages on base of the modern system of equations for wave and particles. An analytical connection for wave, particle and plasma parameters for various phases of the geomagnetic storm is obtained. Possible types of the wave-particle interaction were defined during various stages of storm and substorm development for different local time sectors.

EQUATORIALLY MODULATED PC1 WAVE BURSTS

K. Mursula, R. Rasinkangas and T. Bosinger (Univ. of Oulu, Dept. of Physical Sciences, FIN-90570 Oulu, Finland; Email: Kalevi.Mursula@oulu.fi, Fax: +358 8 5531287)
R. E. Erlandson (Johns Hopkins University, Applied Physics Laboratory, Laurel, MD, U= SA)
P.-A. Lindqvist (Royal Institute of Technology, Alfv=E9n Laboratory, S-10044 Stockholm, Sweden)

On April 11, 1986, from 0650 to 0657 UT, the Swedish Viking satellite observed a chain of bursts of ion cyclotron waves. The strongest bursts can be grouped into two separate wave regions whose properties (e.g. frequencies, normalized frequencies, Alfv=E9n velocities and repetition periods) differed slightly. Most interestingly, we find that the repetition periods of the wave bursts at the two regions are too short to be due to a wave packet bouncing between the hemispheres. Rather, the repetition periods are consistent with equatorial modulation. On ground, Pc1 waves at the same frequency are observed. Moreover, Pc4 waves exist with a period of Viking Pc1 burst repetition rate. We argue that the results undermine the long-held bouncing wave packet hypothesis of Pc1 wave bursts, and discuss alternatives.

THE VLASOV SIMULATION OF PLHR TRIGGERED VLF EMISSIONS OBSERVED AT POROJARVI, FINLAND

D Nunn (Dept of Electronics & C/Sc, University of Southampton, SO17 1BJ, UK)
J Manninen and T Turunen (SGO, Sodankyla, Finland)
V Trakhtengerts (Institute of Applied Physics, Nizhni Novgorod, Russia)
N Erokhin (SRI, Moscow, Russia)

VLF data from Porojarvi, Finland exhibits a wealth of non-linear VLF events involving PLHR. Theoretically interesting cases are shown, such as line drift, emission triggering, capture effects, hiss triggered emissions and triggering of chorus. An established 1D Vlasov (VHS) simulation code is used to simulate band limited triggering events. The VHS method sets up a 4D phase space simulation box which may be a function of time. The trajectories of simulation particles are followed continuously until they leave the phase box. At each time step, the value of F, known for all particles from Liouville's theorem is INTERPOLATED from the particles onto the phase space grid permitting the plasma charge/current field to be calculated. The code integrates the Maxwell and Vlasov equation set, but uses the integral form of the Vlasov equation, namely Liouville's theorem. The method is low noise, highly efficient, and is robust against distribution function filamentation. Using Finnish VLF data, the code has been successfully used to simulate PLHR TEs, emission capture by individual PLHR lines, and triggering by hiss bands. It will be shown that rising frequency emissions and falling tones correspond to different VLF soliton structures that will be described. This work was performed under a collaborative venture financed by INTAS.

QUANTITATIVE MODEL FOR CYCLOTRON WAVE-PARTICLE INTERACTIONS AT THE PLASMAPAUSE

D.L.Pasmanik, V.Y.Trakhtengerts and A.G.Demekhov (Institute of Applied Physics, Nizhny Novgorod, Russia)
M.J.Rycroft (International Space University, Strasbourg, France)

Energetic electron precipitation by a region of enhanced background plasma density, following their injection into the inner magnetosphere during a magnetic storm, is analyzed. Wave-particle interactions by the cyclotron instability are considered as a mechanism of the precipitation. Particular attention is paid to the problem of whistler wave propagation under the plasmapause arch. In the framework of self-consistent equations of quasi-linear plasma theory, the distribution function of trapped electrons together with electron precipitation pattern are found for both weak and strong pitch angle diffusion regimes. A comparison of the theory with experimental data from NOAA satellites is made.

AN INTRODUCTION TO NEW APPROACHES TO STUDIES OF WHISTLER-ELECTRON INTERACTIONS IN THE MAGNETOSPHERE

M.J. Rycroft (International Space University, Parc d'Innovation, Boulevard Gonthier d'Andernach, 67400 Illkirch, France)
V.Y. Trakhtengerts (Institute of Applied Physics, 46 Ulyanov St., 603600 Nishniy Novgorod, Russia)

Attention is focussed here on the quasilinear and non-linear physics of cyclotron interactions between magnetospheric whistler mode waves and energetic electrons on dipolar geomagnetic flux tubes. These interactions can lead to the generation of phase-coherent discrete signals in the frequency-time domain. Examples are ELF/VLF chorus or VLF emissions triggered by whistlers from lightning or by radio transmitters on the ground. Rapid temporal variations of these signals are associated with fine structure of the distribution function of the radiation belt electrons, such as a transient step – like deformation or a well-organised beam, which are prepared by initial noise-like emissions or by a quasimonochromatic whistler – wave packet. These cause the properties of the electrons, which may be observed on a satellite, to evolve rapidly in time and on relatively short spatial scales. Bursts of precipitating electrons occur, and can contribute significantly to depleting the radiation belts. Recent results on improvements in the theoretical understanding of such processes, on new observations of magnetospheric electrons and whistler-mode waves, on related effects in the ionosphere, on wavelet transforms, on fractal dimensional analysis, and on numerical simulations using powerful computers are introduced.

STUDY OF SPATIAL AND TEMPORAL VARIATIONS IN PULSATING AURORA AND ACCOMPANYING ELF-VLF EMISSIONS

V.R.Tagirov, V.S.Ismagilov, E.E.Titova A.A.Perlikov (Polar Geophysical Institute, Apatity, Murmansk region, 184200, Russia)
V.A.Arinin (Russian Federal Nuclear Center, Sarov, 607200, Russia)
T.Turunen, J.K. Manninen (Geophysical Observatory, FIN-99600, Sodankyla, Finland)
K Kaila (University of Oulu, FIN-90570 Oulu, Finland)

Results of simultaneous TV observations of pulsating auroral patches and VLF-emissions in the morning sector carried out in Sodankyla (Finland) on February 15, 1991 are presented. Auroral pulsating activity was typical representing pulsating patches with characteristic periods about 5-10 s. Chorus elements in frequency range 1-2 kHz with periods of 0.3-0.4 s were the main VLF emissions at the same time. The detailed computer analysis of auroral images time resolution (0.04s) allowed perfectly separate spatial and temporal variations in auroral luminosity. Mutual correspondence between the flashing of the patches and appearance of ELF noise type hiss emissions and VLF chorus trains was found out in two intervals chosen for analysis. While the hiss emissions were associated with the appearance of luminosity inside a limited area close to the zenith the structured VLF emissions were accompanied by rapid motion of luminosity inside the area. The spatial dimensions of pulsating area were about 30 km and luminosity propagated inside it with velocity about several km per second.

A GENERATION MECHANISM FOR THE CHORUS EMISSION

V. Y. Trakhtengerts (Institute of Applied Physics, 46 Ulyanov st., 603600 Nizhny Novgorod, Russia)

A chorus generation mechanism is discussed, which is based on interrelation of ELF/VLF noise-like and discrete emissions under the cyclotron wave-particle interactions. A natural ELF/VLF noise radiation is excited by the cyclotron instability mechanism. This process is accompanied by a step-like deformation of the energetic electron distribution function in the velocity space, which is situated at the boundary between resonant and nonresonant particles. The step leads to the strong phase correlation of interacting particles and waves and to a new backward wave oscillator (BWO) regime of wave generation, when an absolute cyclotron instability arises at the central cross-section of the geomagnetic trap in the form of a succesion of discrete signals with growing frequency inside each element. The quantitative estimations of radiation parameters are given, which are in good accordance with the chorus experimental data.

AURORAL ENERGIZATION BY KINETIC ALFVÉN WAVES

J-E. Wahlund, A.I. Eriksson, B. Holback, and A. Olsson (Swedish Institute of Space Physics, Uppsala division, S-755 91 Uppsala, Sweden)
L. Andersson, and L. Eliasson (Swedish Institute of Space Physics, Kiruna Division, Box 812, Kiruna, Sweden)
M.H. Boehm, (NASA, Jet Propulsion Laboratories, U.S.A.)
J.H. Clemmons, (NASA, Goddard Space Flight Center, Greenbelt, U.S.A.)
D. Knudsen, (Department of Physics and Astronomy, University of Calgary, Calgary, Canada)
C.E. Seyler, (School of Electrical Engineering, 306 Eng. and Theory Center, Cornell University, Ithaca, NY 14853, U.S.A.)

High resolution particle and wave measurements made by the Freja spacecraft near an altitude of 1700 km in either the dayside cusp/BL or nighttime northern edge of the auroral zone show simultaneous geomagnetic field-aligned suprathermal electron bursts (up to keV energies), transverse acceleration of ions (TAI, up to a few 100 eV), broadband mostly electrostatic ELF emissions (up to a few kHz) and electromagnetic pulses interpreted as kinetic Alfvén wave pulses (10 Hz in the spacecraft reference frame). The source altitude of the field-aligned electron bursts is estimated to be within 1000 km of the Freja spacecraft, and a partly local energization is indicated. The Poynting flux (10^{-4}-10^{-2} W/m^2) of the "small scale" Alfvén wave pulses are therefore a likely free energy source for a substantial part of the auroral energization. These observational facts will be discussed and interpreted in terms of a scenario where solitary kinetic Alfvén waves (SKAW) are created in the magnetosphere, propagate down the field lines and dissipate its energy.

ANALYSIS OF ELECTRON PRECIPITATION RELATED TO THE WHISTLER CYCLOTRON INSTABILITY IN MAGNETOSPHERE

E.E.Titova (Polar Geophysical Institute, Apatity, Russia)

In this report the cyclotron instability regimes related to the different sources of the energetic electrons are discussed on the basis of the analysis of the coordinated ground-based and satellite observations. Comparison of the different types of energetic electron precipitation and VLF waves at low altitudes with the cold and hot plasma parameters at high altitudes allowed us to select the main factors determining the cyclotron instability regime. In particular, it has been shown that the evolution of the pitch-angle distribution of the drifting electron cloud injected during the substorms is responsible for characteristics of nonstationary precipitation in the morning sector. The importance of the cold plasma gradients in the magnetosphere for the cyclotron instability is demonstrated by consideration of the characteristics of the VLF chorus and quasistationary localized precipitation in the evening sector. Quantitative agreement of the experimental results with the cyclotron interaction models is discussed.

DIGITAL ANALYSIS OF GROUND-BASED NATURAL ULF, ELF AND VLF WAVE EXPERIMENTS USING ORTHOGONAL LOOP ANTENNAE

T. Turunen and J. Manninen (Sodankylä Geophysical Observatory, FIN-99600 Sodankylä, Finland)

Ground based monitoring of ULF, ELF, and VLF waves is commonly done by using two orthogonal horizontal loop antennae as detecting sensors. The arrangement allows determination of signal power, ellipticity, orientation of the polarization ellipse and sense of rotation as a function frequency. Special filtering of the data becomes also possible. One can e.g. select the part of the signal power, which has wanted sense of rotation, ellipticity and orientation of the main axis within the given selectable limits. Meaningful signal to noise improvements can be often obtained if e.g. the unwanted signals are linearly polarized and the wanted signals have more or less circular polarization. The analysis demands, of course, that at any given frequency and time instant the dominating wave arises from a single source. This is not always fulfilled well enough and careful consideration of the physical significance of the obtained results is needed. Very often, however, the analysis produces useful information on the properties of the waves and their source regions. The mathematics behind the processing is briefly described and different examples are given using especially the natural VLF emission measurements as a test data.

DAYSIDE PC5 PULSATION DETECTED BY VIKING ION DATA AT L=4

M. Yamauchi and R. Lundin (Swedish Institute of Space Physics (IRF), Box 812, S-98128 Kiruna, Sweden; Email: yama@irf.se, Fax: +46 980 79050)
K. Mursula (Department of Physical Sciences, University of Oulu, Finland)
G. Marklund (Institute of Plasma Physics, KTH, S-10044 Stockholm, Sweden)
T. A. Potemra (JHU/APL, Laurel, MD 20723-6099, USA)

On September 12, 1986, when the largest magnetic storm (Dst = -157 nT) during Viking operations took place, the satellite observed unusual energy modulation of sub-keV ring current ions. The modulation is seen in both the pitch angle domain (conic-like distribution) and the space-time domain (wavy variation of ion flux with a period of a few minutes). The wavy variation is synchronized with a clear and distinct magnetic field-line oscillation which is probably a standing Alfvén wave. This is observed simultaneously on the ground as a Pc5 pulsation over a wider range of latitude than the satellite observation.

ON THE IDENTIFICATION OF NON-LINEAR INTERACTIONS BETWEEN ELF/ULF TURBULENCES AND IRREGULARITIES IN ELECTRONIC DENSITY

Z. Zaho (Laboratoire de Physique et Chimie de l'Environnement, CNRS, 45071 Orléans cedex 02, France)
F. Lefeuvre, D. Lagoutte, J.L. Rauch (LPCE/CNRS, 45071 Orléans cedex 02 France)

Statistics of order 2 (variance, auto and cross-correlation functions, auto and cross- power spectra) and 3 (skewness, auto and cross- bicorrelation fuctions, auto- and cross-bispectra) are used to analyze AUREOL 3 observations of medium scale electron density irregularities and ELF/ULF electrostatic turbulence. Non-linearities are mainly observed in the ULF range. They are independantly pointed out on time series associated with fluctuations in electronic density and on time series associated with the measurement of one electric field component. Peaks in cross-bicorrelation functions and in mutual information estimators clearly show that, in well delimited frequency bands, the wave-particle interactions are non-linear. Interpretations are proposed in terms of gradient drift instability.

ST10 High-latitude magnetosphere: new results from recent projects

Convener: Yamauchi, M.
Co-Convener: Hoffmann, R.

LOW-ENERGY PLASMA IN THE TERRESTRIAL MAGNETOSPHERE: PRELIMINARY RESULTS OF THE WIDE ANGLE PLANAR MODULATION ELECTROSTATIC ANALYZER ABOARD THE AURORAL PROBE

V. BEZRUKIKH, G. Kotova, L.Lezhen. V.Prokhorenko (Space Research Institute, Profsoyuznaya, 84/32, Moscow, 117810, Russia)
V.Ivchenko (National University of Ukraine, Kiev, Ukraine)
N.Barabanov, Y.Venediktov (State Polytechnical University, Odessa, Ukraine)

The energy spectra of ion fluxes in the range 0- 25.5 eV measured in the deep plasmasphere and in the high-latitude magnetosphere are examined. Differential energy spectra observed at the geocentric distance of ~ 4 Earth radii and geomagnetic latitude of ~ 55 permit to estimate preliminary the flux magnitudes of different ion species (e.g., H+, He+, O+). In some cases the ratio of helium to hydrogen ion fluxes was observed to be as high as 30% and the ratio of nitrogen to hydrogen ion fluxes was as high as 20%.

CASE STUDIES OF THE MAGNETOPAUSE CROSSINGS BASED ON INTERBALL TAIL PROBE AND MAGION-4 SUBSATELLITE DATA

J. Blecki and J. Juchniewicz (Space Research Center, Polish Academy of Sciences, Warsaw, Poland)
M. Ciobanu (Institute of Gravitation and Space Sciences, Bucharest, Romania)
N. V. Ivchenko, V.M. Fedun and M.A. Leonov (Kiev Shevchenko University, Physics Faculty, Kiev, Ukraine)
S. Klimov and S. Romanov (Space Research Institute, Russian Academy of Sciences, Moscow, Russia)
Z. Nemecek and J. Safrankova (Faculty of Mathematics and Physics, Charles University, Prague, Czech R epublic)
J.A. Sauvaud (CESR, Toulouse, France)
P. Triska (Institute of Atmospheric Physics, ASCR, Prague, Czech Republic)

Interball Tail probe was launched together with Magion-4 subsatellite on August 3, 1995. Satellites orbit allows study of the magnetopause in its various regions. Use of two satellites provides a possibility to separate temporal and spatial changes. Several magnetopause crossings in different conditions and in different positions are presented: high latitude, equatorial, subsolar and flank. Magnetopause thickness and motion are estimated. Small scale structure of the magnetopause is described based on magnetic field, wave and plasma data from main satellite and subsatellite.

HIGH LATITUDE MAGNETOPAUSE: INTERBALL-1 OBSERVATIONS AND COMPARISON WITH NUMERICAL SIMULATIONS

J. Büchner, B. Nikutowski, H. Wiechen and J.-P. Kuska (Max-Planck Institut für Aeronomie, Max-Planck-Str. 2, D-37191 Katlenburg-Lindau, Germany)
S. Klimov, S. Romanov and S. Savin (Space Research Institute, Profsoyusnaya ul. 84/32, R-117810 Moscow, Russia)

The highly excentric and inclined INTERBALL-1 orbit allows the investigation of the high latitude flank-and nightside magnetopause. We use this orbit opportunity to analyze magnetic field measurements to investigate the high-latitude morning side magnetopause A minimum variance analysis is carried out to determine the boundary layer normal direction. As a result the variation of the magnetic fields can be presented in the boundary-normal-coordinate system. One magnetopause crossings indicates a rotational discontinuity, while the remaining ones correspond to a tangential discontinuity type boundary. In order to understand the reason for the observed field structure we have carried out appropriate MHD simulations. The results of an intercomparison between measurements and simulations are presented.

Initial Results from the Fast Auroral Snapshot Mission

C W. Carlson, R.E. Ergun, J.P. McFadden, C. Chaston, G. T. Delory, W. Peria, F.S. Mozer, M Temerin, (University of California, Berkeley); R. Elphic (Los Alamos National Laboratory); R. Strangeway (University of California, Los Angeles); D.M. Klumpar, E.G. Shelley, W.K. Peterson (Lockheed Martin Palo Alto Research Laboratory); E. Moebius, L. Kistler (University of New Hampshire); C. Cattell (University of Minnesota); R. Pfaff (Goddard Space Flight Center)

The Fast Auroral Snapshot (FAST) satellite, the second of the NASA Small Explorer Missions, was successfully launched on August 21, 1996, into a high inclination, 350 x 4200 km orbit. The primary scientific objective of the FAST mission is to investigate the plasma micro-physics of the mid-altitude auroral zone. The FAST instruments have been designed to emphasize rapid field and charged particle measurements. Plasma particle measurements are performed by a set of 16 electrostatic analyzers, configured as electron/ion spectrometers and electron spectrographs. Mass resolved ion distribution functions are measured by a time-of-flight mass spectrograph. Double probe antennas perform full vector DC and wave electric fields, and a combination of fluxgate and searchcoil magnetometers measure the DC and AC magnetic fields. Measurement time scales are as rapid as 80 ms for ion distributions, 2 ms for electron distributions, and 0.1 ms for electric fields structures. Wave measurements extend to 300 kHz for magnetic fields and 2 MHz for electric fields. Burst data rates of 1 Mbyte/sec are made possible by use of a one Gigabyte solid state memory. On-board processing is used to select burst "snapshots" for the highest time resolution events. Early observations include detailed wave and particle measurements within auroral kilometric radiation (AKR) regions, ion conic heating events, and magnetic field-aligned electron beams. One of the most surprising results has been the discovery of intense spikes of magnetic field-aligned electrons with durations of a few ms that are accompanied by large amplitude, 100 microsecond duration solitary waves.

THERMAL ION MEASUREMENTS ON INTERBALL AURORAL PROBE

N. Dubouloz, M. Malingre, Jean-Jacques Berthelier and D. Delcourt (CETP/CNRS, 4 avenue de Neptune, 94107 Saint-Maur-des-Fossés, France)
Y. Galperin, T. Mularchik and D. Chugunin (IKI, Profsouznaya 84/32, GSP-7, Moscow, Russia)

The payload of the INTERBALL Auroral Probe includes a thermal plasma experiment (HYPERBOLOID) devoted to the measurement of 0-80 eV major ions (H^+, He^+, O^{++}, O^+). Ion distributions in two perpendicular planes can be obtained with time resolution of a few seconds, while full 3D distributions are obtained in one spin period (120 s). Detection of low energy ions is enabled by the coordinated use of an ion beam source controlling the satellite potential (RON experiment, Space Research Institute, Austrian Academy of Science, Graz). Moments are calculated routinely and provide density, bulk velocity vector and temperature for each ion species. Preliminary results show interesting features such as polar wind, auroral heating, and bi-directional H^+ and He^+ distributions at subauroral latitudes.

PARTICLE MEASUREMENTS AT THE HIGH LATITUDE MAGNETOPAUSE: RESULTS FROM PROMICS-3 ONBOARD INTERBALL

U. Eklund and I. Sandahl (Swedish Institute of Space Physics, Kiruna, Sweden)

The PROMICS-3 instrument, onboard the Interball tail probe, has produced interesting particle data with better time, energy and mass resolution than previously availible from other satellites flown in similar orbits. The PROMICS-3 instrument is able to detect ions, with mass separation, in the energy range 4eV to 70keV, and electrons in the energy range 12eV to 35keV. The time resolution of the PROMICS-3 instrument, 9.6 seconds for a full mass and energy sweep in the fastest mode, makes it possible to use the data gathered for studies of meso-, and microscale physics in the interaction between the high-latitude magnetosphere and the solar wind. Correlated studies between the PROMICS-3 instruments on Interball tail and auroral probes may also prove valuable. Some examples of high resolution data when Interball tail passes through the magnetopause near the outer cusp and the entry layer are presented.

A COMPARISION OF OPEN/CLOSED FIELD LINE BOUNDARIES AS SEEN BY THE CEPPAD AND HYDRA INSTRUMENTS ON POLAR

R. H. W. Friedel (Max-Planck-Institute for Aeronomie, 37189 Lindau, Germany)
J. Fennell (The Aerospace Corporation, El Segundo, California, USA)
C. Mouikis and A Korth (Max-Planck-Institute for Aeronomie, 37189 Lindau, Germany)
J. Scudder (University of Iowa, Iowa City, Iowa, USA)

POLAR offers a new chance at systematically charting the open/closed field line boundary as seen by energetic and plasma particle instruments, and to do so over a wide range of magnetic latitudes. The energetic particle instrument CEPPAD is used to obtain the primary deliniation of the boundary position, while the plasma instument HYDRA is used to compare this boundary position to typical plasma sugnatures of the boundary layers that are crossed when POLAR moves from open to closed field lines. Finally we will attempt order the boundary position by magnetospheric control paramters such as solar wind speed and direction.

POLAR MAGNETOSPHERE DURING A SOLAR MINIMUM - A LOOK FROM THE INTERBALL–2

Yu. I. Galperin (Space Research Institute of Russian Academy of Sciences, Profsoyuznaya str., 84/32, 117810, Moscow, Russia)

Quiet Sun during the first months of the INTERBALL–2 led to a relatively quiet magnetosphere with only rare convection surges. This allowed for long plasma accumulation times, an extended and dense plasmasphere, and classic polar wind beams of H^+ and He^+ with low scattering. This thermal plasma environment modified characteristics of wave-particle interactions, the plasma wave environement in the near-Earth magnetosphere, typical boundaries locations of the main magnetospheric plasma domains. These new features of the magnetosphere during solar minimum are briefly reviewed from the data of the INTERBAL–2 measurements.

COORDINATED STUDIES OF PLASMASHEET DYNAMICS DURING SUBSTORM GROWTH USING POLAR AND GEOTAIL

M. Grande, B.J. Kellett, M.K. Carter and C.H. Perry (Space Science Dept., Rutherford Appleton Lab., Chilton, Didcot, Oxfordshire OX11 0QX, UK)
S. Chapman and D. Billington (Warwick University, UK)
B. Wilken, J. Woch and R. Freidel (Max Plank Institute fur Aeronomie, Lindau, Germany)
A. Hall, S. Cowley and M. Lester (University of Leicester, UK)

We are undertaking a series of coordinated Polar/Geotail/Groundbased observations. The POLAR orbit is such that the spacecraft passes through the plasmasheet boundary layer in the northern hemisphere on the nightside at L-shells of 5 - 20 and radial distances of 4 - 6 RE, respectively. Geotail is at present in an equatorial 20 x 10 RE orbit. These high latitude passes represent an excellent opportunity to investigate the
changes in plasma composition as well as the behaviour of the PSBL during periods of substorm growth. During such periods, we observe signatures of similar PSBL structures at both Polar and Geotail . These observations can be interpreted as the signatures of distant reconnection events.

MAGNETOSHEATH ION POPULATIONS SEEN ON 29 MAY AND 20 JUNE 96

M. Grande, B.J. Kellett and C.H. Perry (Space Science Dept., Rutherford Appleton Lab., Didcot, Oxon. OX11 0QX, UK)
J. Fennell (Aerospace Corporation, Los Angeles, CA, USA)
S. Livi (Max Plank Institute fur Aeronomie, Lindau, Germany)
H. Spence and T. Fritz (Boston University, Boston, MA, USA)

On 29 May 96 and 20 Jun 96 the Polar spacecraft appeared to cross into an extended cusp or magnetosheath region, characterised by boundaries seen in the angular distributions of particles in the energy range 1-10keV and magnetosheath ion compositions. We are combining these observations with those from the HEO spacecraft to examine the spatial extent and characteristics of this region which may be produced by northward IMF interacting with the northern cusp. We will present particle data identifying the composition of ions, as well as combined information from both spacecraft, indicating a considerable spatial extent for the region observed.

AURORAL KILOMETRIC RADIATION AS SEEN FROM THE AURORAL PROBE (INTERBALL-2)

J. Hanasz (Space Research Centre P.A.S., ul. Rabianska 8, 87-100 Torun, Poland)
R. Schreiber (Copernicus Astronomical Centre P.A.S., ul. Rabianska 8, 87-100 Torun, Poland)
M. M. Mogilevsky and T. V. Romancova (Space Research Institute R.A.S., ul. Profsoyuznaya 84/32, 117810 Moscow, Russia)
H. de Feraudy (CETP/CNRS, 10-12 av. de l'Europe, 78140 Velizy, France)

Intense AKR has been observed at frequencies between 40 and 700 kHz with POLRAD - a swept frequency analyser of 4 kHz filter bandwidth. The sources of AKR can be met as high as 17 000 km above the Earth's surface. Examples of the isolated narrowband filamentary structures lasting for about 1 minute and drifting at about 100 kHz/min. from low to high frequencies are seen. Steep upper frequency limits of the AKR are often observed. They are manifested by the power cutoffs of sometimes more than 4 orders of magnitude over 4 kHz bandwidth of the filter. This can evidence that the AKR sources may have precisely defined bottoms. Powerful "flashes" of AKR, one pixel wide (4 kHz vs. 6 seconds) are frequently seen a few orders of magnitude over the background of the wideband radiation. They suggest narrow radiating structures with altitude extensions of less than 100 km.

ION COMPOSITION IN THE HIGH-LATITUDE NIGHTSIDE MAGNETOSPHERE: OBSERVATIONS FROM CAMMICE/MICS ON BOARD THE POLAR SPACECRAFT

G.Kettmann[1], J. Woch, U.Mall, N. Krupp, S. Livi, B. Wilken (all at: Max-Planck-Institut für Aeronomie, Postfach 20, D-37189 Katlenburg-Lindau, Phone: +49-5556-979-338, E-Mail: Kettmann@linax1.mpae.gwdg.de; [1]: also at Max-Planck-Insitut für Extraterrestrische Physik)
T.A. Fritz (Center for Space Physics, Boston University, Boston, MA 02215, USA)
J.F. Fennell (The Aerospace Corporation, Los Angeles, CA 90009, USA)

By means of an electrostatic analyser and combined energy and time-of-flight measurements, the Magnetospheric Ion Composition Spectrometer (MICS) which is part of the CAMMICE experiment on board the POLAR spacecraft allows an identification of ions in the energy range of 1 - 400 keV per charge in terms of their mass and mass per charge. This technique permits us to separate low and high charge state ions and to conclude on the source of the measured ions. First MICS results on the ion composition in the high-latitude nightside magnetosphere are presented. In particular, we concentrate on the oxygen contribution in the various plasma regimes and delineate between ionospheric and magnetotail sources. We investigate the dependence of the composition on geomagnetic activity.

THE STUDY OF THE IONOSPHERE IN THE CUSP REGION ACCORDING TO THE DMSP AND COSMOS-900 SATELLITES

V. Khalipov, L.Shestakova, A.Stepanov, D.Fedoseev (Institute of Cosmophysical Research and Aeronomy, Lenin Ave., 31, 677891, Yakutsk, Russia)
D.Sibeck (APL, Johns Hopkins Road, Laurel MD 207 23, U.S.A.)
V.Afonin (Space Research Institute, Profsoyuznaya, 84/32, Moscow, 117810, Russia)

Simultaneous measurements of the thermal electron temperature T and density N aboard the Cosmos-900 satellite and energetic electron and ion fluxes aboard the DMSP satellite are analyzed during the intense geomagnetic storm development. The specific peaks in T and N profiles are described at the heights close to the F-layer maximum in the region of the noon polar cusp. The latitudinal distributions of T and N near the cusp at different heights are determined by the field-aligned and cross-field transport of plasma, intense recombination caused by the T increase, and delay in ionospheric processes under the action of the powerful corpuscular source in the cusp. The model calculations taking into account these factors are performed.

INTERBALL OBSERVATIONS OF THE HIGH-LATITUDE MAGNETOSHEATH

S.I.Klimov (Space Research Institute, Profsoyuznaja str., 84/32, 117810 Moscow, Rus sia)
S.A.Romanov, M.N.Nozdrachev, N.S.Nikolaeva, A.A.Petrukovich, S.P.Savin, A.A.Skalsky, Yu.I.Ermolayev, G.N.Zastenker, L.M.Zelenyi, V.A.Grushin and N.E.Ry bjeva (Space Research Institute, Profsoyuznaja str., 84/32, 117810 Moscow, Ru ssia)
J.Blecki, J.Juchniewicz, K.Kossacki (Space Research Centre, Polish Academy of Sciences, Warsaw, Poland)
P.Triska (Institute of Atmospheric Physics, Praha, Czech Republic)
Z.Nemecek, J.Safrankowa (Charles University, Praha, Czech Republic)
M.Ciobanu (Institute of Gravitation and Space Sciences, Bucharest,Romania)
R.P.Lepping (NASA GSFC, Greenbelt, USA)
S.Kokubun (STELAB Nagoya University, Japan)

The orbits of the Interball-1 and Magion-4 sub-satellite are favorable f or carrying out magnetosheath (MSH) turbulence research at the high and low lat itudes, their dependence on the bow shock (BS) and magnetopause (MP) geometry an d on the characteristi

INTERBALL-TAIL COLD ELECTRON OBSERVATIONS IN THE MID-TAIL MAGNETOSPHERE

P. Koperski and J.-A. Sauvaud (Centre d'Etude Spatiale des Rayonnements, Toulouse, France)
N. Borodkova and O. Vaisberg (Space Research Institute, Moscow, Russia)

The Interball-Tail satellite observations, performed with the "Electron" experiment in the magnetosphere are presented. In the mid-tail region (about 10 to 25 RE), different plasma domains were observed, in correlation with different phases of geomagnetic activity. There is an evidence of cold plasma (electrons) outside of the Plasma Sheet, different than typical Plasma Sheet Boundary Layer bidirectional electron beams. Characteristic properties of these electrons (low temperatures downto 70 eV and less, field-aligned anisotropy weaker than typically in the PSBL, frequently nonthermal kappa-like distribution functions) are presented, together with relations to spacecraft position and substorm activity phase (PS thining and some injection events).

MULTICOMPONENT WAVE MEASUREMENTS ON-BOARD INTERBALL 2 : THE MEMO EXPERIMENT

F Lefeuvre (Laboratoire de Physique et Chimie de l'Environnement, CNRS, 45071 Orléans cedex 02, France)
M. Parrot, J.L. Rauch, B. Poirier, J.P. Dume, P. Fergeau, M. Léveque, Ph Martin, J.M. Moreau, P. Zamora (LPCE/CNRS, 45071 Orléans cedex 02 France)
M. Mogilevsky (Space Research Institute of Russian Academy of Sciences, Profsoyusnaya str., 84/32, Moscow, 117810, Russia)

The MEMO experiment (MEsure Multicomposante des Ondes) consists of two sets of magnetic sensors, including ULF/ELF (0.1 Hz-1.0 kHz) triaxial search-coil magnetometer and three separate HF (40 kHz-2 MHz) search-coil magnetic antennas, as well as a processing unit. Interfaced with other wave experiments (POLRAD, NVK-ONCH, IESP), it is mainly design to transmit waveforms of two to five electromagnetic field components, in the frequency range 5Hz-250 kHz, over short time intervalls. The experiment is briefly described. First results are presented with an emphasis on Auroral Kilometric Radiations and associated VLF and ELF emissions.

HIGHLIGHT OF THE FIRST EGS Alfvén CONFERENCE

R. Lundin and M. Yamauchi (Swedish Institute of Space Physics (IRF), Box 812, S-98128 Kiruna, Sweden)
D. Sibeck (JHU/APL, Laurel. Maryland, USA)
L. Lyons (Aerospace Corp., Los Angeles, California, USA)

The first EGS Alfvén Conference on "Low-Altitude Investigation of Dayside Magnetospheric Boundary Processes" was held in Kiruna, Sweden, during 9-13 September, 1996, in honour of the late Hannes Alfvén , one of the founding fathers of Space Physics. The conference was designed with two key objectives in mind: (1) to provide an opportunity for theorists and satellite and ground researchers to establish new contacts and (2) to identify crucial unresolved problems and discuss the means by which they might be addressed. Restrictive assumptions used for measurements and modeling were another major concern at this conference. The unique feature of the conference was a series of discussion hours which were designated to help mutual understanding of contending physical explanations of specific phenomena.
Details of the meeting are found in semi-permanently continued WWW pages (http://www.irf.se/conference and ftp://epac.irf.se/pub/conference). The second EGS Alfvén Conference will be held sometime in 1998 to discuss acceleration processes of plasma. Researchers interested this meeting are invited to contact the Alfvén laboratory (alfven-conf2@plasma.kth.se).

ENERGETIC PARTICLE JETS ENCOUNTERED DURING ENERGETIC PARTICLE DROPOUTS OBSERVED BY CRRES USING ION COMPOSITIONS MEASUREMENTS OF THE MICS INSTRUMENT

C Mouikis, R. H. W. Friedel, B. Wilken and A. Korth (Max-Planck-Institute for Aeronomie, 37189 Lindau, Germany)
J. Fennell (The Aerospace Corporation, El Segundo, California, USA)
M. Grande (Rutherford Appelton Laboratory, Ditcot, England)

Energetic particle dropouts are observed by CRRES over a wide energy range from eV to MeV and with a variety of instrumens (LEPA, MEB, MEA, MICS). They represent a reduction of particle fluxes in the observed energy range to background levels. These dropouts are associated with disturbed periods when the satellite is believed to enter into the plasma sheet boundary layer or even into the lobes. We use here the ion composition measurements of MICS to categorise the dropouts according to composition and try to establish the boundary regime being sampled. Often CRRES sees energetic particle jets within these boundaries, which are characterised by their composition and flux levels to be different from pre-dropout distributions. Using the direction information of MICS an attempt is made to identify the source for these jets.

OMNIDIRECTIONAL MASS SPECTRA FROM THE TIMAS INSTRUMENT ON GGS/POLAR

O.W. Lennartsson, H. L. Collin, J. F. Drake, A. G. Ghielmetti, W.K. Peterson and E.G. Shelley (all at Lockheed Martin Missiles and Space, Palo Alto, CA 94304, U.S.A.)
H. Balsiger (Univ of Bern, Sidlerstr 5, 3012 Bern, Switzerland)

The Toroidal Imaging Mass-Angle Spectrograph (TIMAS) on the ISTP/GGS Polar spacecraft is the first spaceborne ion composition analyzer for keV-type plasmas to measure over virtually the entire unit sphere in velocity space. It does so by having a 10° by 360° instantaneous field-of-view nearly parallel to the Polar spin axis, resulting in a 98% coverage of the unit sphere during the 6-second spin period. Like most of its predecessors with smaller fields-of-view, this analyzer selects the ions by their E/Q, specifically in the range from 15 eV/e to 33 keV/e, and M/Q, but unlike those earlier instruments, it records different ions all at once, by dispersing them according to M/Q on a position-sensitive detector, thereby greatly improving the time resolution. At the present time it is measuring the geospace ion composition during conditions of minimum solar activity. An initial survey of this composition shows a rather strong dominance of protons at all measured energies, except below a few hundred eV/e over the polar caps, where singly charged oxygen ions often have comparable fluxes. Singly and doubly charged helium ions are generally present in a varying ratio, and molecular ions with M/Q near 30 are seen occasionally, but doubly charged oxygen ions are almost absent in these data.

ION ACCELERATION FEATURES IN THE CUSP REGION: OBSERVATIONS BY CAMMICE/MICS ON BOARD POLAR

U.Mall, J. Woch, G. Kettmann, N. Krupp, S. Livi, B. Wilken (all at: Max-Planck-Institut für Aeronomie, Postfach 20, D-37189 Katlenburg-Lindau, Phone: +49-5556-979-152, E-Mail: Mall@linax1.mpae.gwdg.de)
T.A. Fritz (Center for Space Physics, Boston University, Boston, MA 02215, USA)
J.F. Fennell (The Aerospace Corporation, Los Angeles, CA 90009, USA)

The Magnetospheric Ion Composition Spectrometer (MICS) of the CAMMICE experiment on board the POLAR spacecraft uses a time-of-flight and solid state detector technique in order to determine the mass and charge state of ions in an E/Q range between 1 - 400 keV/e. With MICS it is possible to observe magnetosheath ions and the core of the ring current distribution with one single instrument. In this preliminary study, we investigate particle signatures associated with the cusp region. We will specifically concentrate on patches of accelerated ions observed at the equatorward boundary of the cusp precipitation region during times of southward IMF. These ions have energies of at least several tens of keV, occasionally exceeding even 100 keV which is considerably higher than expected from recent models of magnetopause reconnection. The origin of these energetic ions is discussed.

POLAR UVI and DMSP Observations: Comparison with A Unifying Dynamic Polar Cap Model

P. T. Newell and C.-I. Meng (Johns Hopkins Applied Physics Laboratory, Laurel, MD 20723), G. K. Parks (U. Washington, Seattle, WA 98195)

A model of polar cap dynamics which takes into account the greatly different rates at which flux can be opened on the dayside (~10^5 Webers/s) versus the quiet time closure rate (~$7x10^3$ Webers/s), and the geoeffectiveness of relatively brief (~5 minutes) IMF fluctuations has had good success reconciling apparently conflicting reports about polar cap morphology. Even brief fluctuations southward during prolonged intervals of northward IMF can open the polar cap, hence it is rare for the polar cap to be completely closed even after days of magnetic quiet; yet 4-5 hours of continuously large and positive Bz (without excursions towards zero) are sufficient to completely close the polar cap (in which condition plasma sheet ions and electrons stretch across the entire polar cap with no appreciable gaps). Polar cap arcs become well separated from the main oval only during intervals appropriate to dayside merging. The Polar satellite UVI imager combined with DMSP observations provides new opportunities to test this model. The most recent results will be presented.

ULF WAVES MEASUREMENTS ON-BOARD INTERBALL 2: IESP EXPERIMENT

S. Perraut, A. Roux, A. Bouabdellah, B. de la Porte (CETP/UVSQ, 10-12,Avenue de l'Europe- 78 140 Velizy, France), M. Mogilevsky (Space Research Institute of Russian Academy of Sciences, Profsoyusnaya str., 84/32, Moscow, 117810, Russia), F. Lefeuvre (Laboratoire de Physique et Chimie de l'Environnement, CNRS, 45071 Orleans Cedex 02, France)

The IESP experiment detects the 6 electromagnetic components in the frequency range from 0.1 to 30 Hz on-board the Auroral Probe of the Interball space mission. The trajectory is such that it crosses regions where acceleration processes of the electrons producing auroras take place. Several mechanisms have been proposed to account for the presence of parallel electric fields, including electromagnetic structures (kinetic Alfven wave) and electrostatic shocks. Thanks to the simultaneous observation of electric and magnetic components we can decide between the two possibilities.

STRUCTURE OF THE EARTH RING CURRENT DURING 1995-1996: INTERBALL TAIL-PROBE OBSERVATIONS.

N.Pissarenko, E.Morozova, A.Moszhukhina, E.Dubinin, E.Budnik (Space Research Institute, Moscow,117810, RF)
I.Sandahl, E.Eklund (Swedish Institute of Space Physics, P.O.Box 812, S-981 28 Kiruna, Sweden
T.Pulkkinen (Finnish Meteorological Institute, P.O.Box 503, SF 001 01, Helsinki, Finland)

It was found that the spatial distribution of trapped charged particles in the Radiation Belts (RB) and Ring Current (RC) demonstrates stable shape for L<5 and for L>5 the distant part of RC is almost always unstable . These distant parts of RC are similar to comet tail : they permanently produce clouds or plasmoids in night side regions (from 6 to 18 MLT). The characteristics of the structure RC were investigated for all MLT.

FIRST RESULTS FROM THE PROMICS-3 INSTRUMENT ON INTERBALL AURORAL PROBE

Ingrid Sandahl (Swedish Institute of Space Physics (IRF), Box 812, S-98128 Kiruna, Sweden; ingrid@irf.se)

Interball Auroral Probe was launched on August 29, 1996. Apogee is at about 20 000 km and the orbit period about 6 hours. On board the satellite PROMICS-3-Auroral measures ions with mass resolution in the energy range 4 eV to 70 keV and electrons between 12 eV and 35 keV. The instrument is a result of a cooperation between the Swedish Institute of Space Physics in Kiruna, the Finnish Meteorological Institute in Helsinki and the Space Research Institute in Moscow. An identical instrument by the same team flies on Interball Tail Probe.
PROMICS-3-Auroral is working nominally and is producing good data. Among the early measurements include upward oxygen beams in the energy range 50 eV to 1.5 keV over the polar cap. In this paper initial results will be reviewed, with particular emphasis on studies using PROMICS-3-Auroral data in combination with data from other satellites at higher altitudes.

HYDROGEN BEAMS ON THE POLEWARD SIDE OF PROTON AURORA: TEMPORAL EFFECT

J.-A. Sauvaud and P. Koperski (Centre d'Etude Spatiale des Rayonnements, Toulouse, France)
R.A. Kovrazhkin and K. Afanasiev (Space Research Institute, Moscow, Russia)

The Interball-Auroral first observations in the auroral zone, performed with the "ION" experiment at altitudes of the order of 2-3 Earths radii are presented. A very clear result, obtained in the morning part of the auroral zone, is the unexpected detection of temporal dispersions of proton precipitation which cause an energy dispersion at the satellite altitude. Simultaneous electron measurements indicate that the field lines are closed. These time of flight effects detected for the proton precipitation allow to compute easily the distance at which the ions are injected: 60 to 100 RE for an invariant latitude of 72.4 and a local time of 06 H. This corresponds to field lines crossing the magnetic equator at distances higher than 50 RE. These structures last for about 4 minutes and have a recurrence period of 1-2 minutes. The energy distribution of the dispersed ions is quite similar to that of the uniform proton aurora which leads to propose a mechanism based on a topological deformation of the field line of the flank of the magnetosphere to explain the observations.

THE HIGH-ALTITUDE CUSP

J. Šimůnek (Institute of Atmospheric Physics, 14131 Praha 4, Czech Republic)
J. Měrka, J. Šafránková, Z. Němeček, A. Skalský (Faculty of Mathematics and Physics. Charles University, 180 00 Praha 8, Czech Republic)
N.Rybeva (Institute of Space Physics, 117810 Moscow, Russia)

During the last thirty years numerous satellites orbiting in low and middle altitudes have accumulated a large amount of information on cusp precipitation and its response to changing conditions in the interplanetary medium. But a general knowledge of processes occurring at altitudes where the magnetosheath plasma enters into the cusp-region is rather poor. Two INTERBALL Project satellites, Interball 1 and MAGION 4, moving along essentially the same orbit with a relative small distance between them, often spent continuously a few hours in the cusp region. This made possible to get two point simultaneous measurements of the radial profile of the cusp region up to the magnetopause. This contribution deals with magnetic field fluctuations on the cusp-magnetosheath boundary which are connected with dynamic changes of the plasma flow. A preliminary analysis of the data shows the presence of a broad region of the mixed plasma population. The position of this region is a function of coordinates and the IMF direction but is less sensitive to changes of the solar wind dynamics.

THREE DIMENSIONAL PLASMA MEASUREMENTS IN THE CUSP REGIONS: POLAR/TIMAS RESULTS

K.J. Trattner, A.J. Coates, A.N. Fazakerley, A.D. Johnstone and I.C. Kraklis (Mullard Space Science Lab, UCL. Dorking, UK)
H. Balsiger (Physicalisches Institut, Bern, Switzerland)
J.L. Burch (Southwest Research Institut, San Antonio, USA)
H. Rosenbauer (Max Planck Institut, Lindau, Germany)
E. Shelley (Lockheed Martin Laboratory, Palo Alto, USA)

Regions of special interest within our magnetosphere include the magnetic cusps. While in the cusps, magnetosheath plasma has more or less direct access to the inner magnetosphere, the edge of the cusps represent the magnetic foot prints of the entire magnetopause. This makes the cusps ideal spots to study magnetic reconnection at the magnetopause, plasma entry into the magnetosphere and the plasma signatures of the magnetospheric boundary layers.
The Toroidal Imaging Mass-Angle Spectrograph (TIMAS) on the Polar spacecraft covers the energy range from 15 eV/e to 33 KeV/e. During its 6-second spin period, it provides a 98% coverage of the unit sphere. Using TIMAS observations of H^+, He^+, He^{++} and O^+ we will present the latest results on Polar cusp crossings. The data will be compared with measurements from other satellites (e.g. Interball).

STUDY OF HIGH-LATITUDE MAGNETOSPHERE REGIONS USING MAGION 4 OBSERVATIONS

P. Tříska, (Institute of Atmospheric Physics, 141 31 Praha 4, Czech Republic)
Z. Němeček (Faculty of Mathematics and Physics. Charles University, 180 00 Praha 8, Czech Republic)
J. Blecki (Space Research Centre PAS, 00716 Warsaw, Poland)

MAGION 4 (60 kg) was launched on 3 August, 1995, together with the INTERBALL 1 satellite into an orbit with apogee 192000 km, perigee 793 km and inclination 62.9°. The scientific payload of is aimed to measure plasma parameters, wave phenomena and magnetic field fluctuations and thus it can provide a rather complete information on the physical phenomena in regions under study. The orbital plane relative movement during the year allows to cross different magnetosphere regions as well as magnetospheric boundaries. MAGION 4 maneuvering possibility was used to control the distance between the two INTERBALL-Tail s/c moving along the same orbit. The distance was increased up to 10000 km for Earth's magnetotail investigation and decreased again in favor of small structure studies of magnetopause and bow-shock regions. An overview of some of these measurements will be given in this paper. The preliminary analysis of data shows that the structure of high-latitude magnetopause differs substantially from that in the lower latitudes, e.g. Plasma waves observations during polar cusp crossings include broad band emissions with characteristic maxima at lower-hybrid and electron-cyclotron frequencies.

ACTIVE S/C POTENTIAL CONTROL ON INTERBALL-2: FIRST RESULTS AND MODELLING OF EFFECTS ON ION MASS-SPECTROMETRY

M. V. Veselov, V. V. Afonin, Yu. I. Galperin and L. V. Zinin (Space Research Institute RAS, 117810, Profsojuznaya st. 84/32, Moscow, Russia)
H. Arends, A. Pedersen and R. Schmidt (Solar System Division, SSD ESA, ESTEC, Keplerlaan 1, NL-2200 AG Noordwijk, The Netherlands)
M. Fehringer and F. Ruedenauer (Austrian Research Centre Seibersdorf, A-2444 Seibersdorf, Austria)
W. Riedler and K. Torkar (Space Research Institute, Austrian Academy of Sciences, Inffeldgasse 12, A-8010 Graz, Austria)

The first results on the S/C electric potential in respect to plasma from the INTERBALL–2 satellite (Auroral Probe) are presented and analyzed together with the data on thermal plasma. A specific feature of the INTERBALL–2 is the ability to regulate the potential by a controllable ion beam (N_2^+, 5 keV) emitted by the RON experiment. The data indicate relatively low S/C potentials till the apogee (~ 19000 km). Possible influence of the S/C potential on the onboard thermal plasma measurements by the HYPERBOLOID energy-angle-mass-spectrometer is analyzed using computer models for Debye lengths equal to zero and more than 30m. The modelling indicates that very peculiarly distorted ion pitch-angle distributions can be registered from a charged spacecraft for particular choices of parameters for anisotropic ambient ion distributions. Thus the importance of the S/C potential control for the thermal plasma ion mass-spectrometry is stressed.

AN ISOLATED SUBSTORM IN THE INITIAL PHASE OF A CIR - HEP-LD/GEOTAIL OBSERVATIONS IN THE DISTANT TAIL

B. Wilken (Max-Planck-Institut für Aeronomie, D-37191 Katlenburg-Lindau, Germany)
Q.-G. Zong (Max-Planck-Institut für Aeronomie, D-37191 Katlenburg-Lindau, Germany)
T. Doke (Waseda University, Japan)
T. Mukai,T. Yamamoto (ISAS, Tokyo, Japan)
G. Reeves (Los Alamos National Laboratory, USA)
S. Ullaland (University of Bergen, Norway)

On January 11, 1994 an interplanetary corrotating interaction region (CIR) reached the Earth magnetosphere. Ground based magnetometers and geosynchronous satellites detected the development of an isolated substorm at 14:00 UT. GEOTAIL was located in the distant tail (GSE: -91 , 15.5, -3.5 Re) in or near the plasma sheet at this time. The HEP-LD spectrometer on board GEOTAIL observed a nearly isotropic flux increase for energetic protons and helium ions in close coincidence with the growth phase of the substorm (particle drop out in the Geostationary orbit). An unusual feature is the high helium abundance in this case. Within a few minutes of the injection at 6.6 Re HEP-LD observed the appearence of energetic oxygen ions with a very high tailward anisitropy. The streaming ions are accompanied by plasmoidal structures in the magnetic field.

PLASMOIDS BOUNDARY STRUCTURE: GEOTAIL OBSERVATIONS

Q.-G. Zong (Max-Planck-Institut für Aeronomie, D-37191 Katlenburg-Lindau, Germany)
B. Wilken (Max-Planck-Institut für Aeronomie, D-37191 Katlenburg-Lindau, Germany)
G. Reeves (Los Alamos National Laboratory, USA)
T. Doke (Waseda University, Japan)
T. Mukai,T. Yamamoto (ISAS, Japan)
S. Kokubun (STEL, Nagoya University, Japan)
S. Ullaland (University of Bergen, Norway)

The GEOTAIL satellite experienced numerous encounters with energetic oxygen burst in distant magnetotail. Those energetic oxygen ion bursts usually related to substorm signatures, lasted on 20 to 30 minutes and exhibited strong beam-like structures. A clearly energy dispersion was exhibited in two cases of them (Jan.15 and Feb.13,1994). Those two oxygen ion bursts are single-peaked and peak in energy up to 250 Kev. The three-dimensional distributions shows that they are highly collimated and exhibit beamlike characteristics. The streaming direction of the observed energetic ion beam are parallel or antiparallel to magnetic field. Thus assuming the existence of a general ion source function, then, we can estmate where the acceleration source located.

ST11 The polar ionosphere and magnetosphere

Convener: Villain, J.-P.
Co-Convener: Woch, J.

COMPLEX INVESTIGATIONS OF THE SAR-ARCS ABOVE THE YAKUTIA REGION

V. V. Afonin (Space Research Institute, Profsoyuznaya, 84/32, Moscow, 117810, Russia)
V. Khalipov, V. N. Alekseev (Institute of Cosmophysical Research and Aeronomy, Lenin Ave., 31, 677891, Yakutsk, Russia)

Ground based observations of SAR-arcs at the meridian of Yakutsk (λ=130E, L=3.3) during 1989 - 1992 and simultaneous measurements of electron density and temperature on board Activny and APEX satellites are analyzed. The data showed that in the periods of moderate geomagnetic activity the SAR-arc appeared in the region of polarization jet (SAJD-condition) in the dusk sector at L ~ 3.5-4.0. The emission at 630 nm and heating of neutral and charged particles is mainly caused by the strong local electric field (~ 100 mV/m). In storm conditions the SAR-arcs displace to L ≤ 2.5 - 3.0 and the energy source of ring current dissipation begins to act.

MESO-SCALL ION AND ELECTRON OBSERVATIONS IN THE CUSP REGION BY THE FREJA SATELLITE

L. Andersson, M. Yamauchi and L. Eliasson (Swedish Institute of Space Physics (IRF), Box 812, S-98128 Kiruna, Sweden; Fax: +46 980 79050)
J. H. Clemmons (NASA/GSFC, Greenbelt, MD 20771, USA)
M. Boehm (JPL, Pasadena, CA 91109, USA)
J.-E. Wahlund (IRF-Uppsala, S-75590 Uppsala, Sweden)
L. Blomberg (Institute of Plasma Physics, KTH, S-10044 Stockholm, Sweden)

Particle signatures in the cusp and the boundary cusp are studied using high-resolution particle and field data from the Freja satellite. Three major observational results are: (1) Electron energy-pitch angle distribution often shows a uniform and steady potential drop of nearly 100 eV, sometimes up to 200 eV, in the cusp proper. (2) We, for the first time, find a subsequent electron dispersion and proton dispersion in the cusp. However, those electrons and protons come from completely different sources, and this is supported by the field data. This raises a question on the source of the aurora-electrons in the cusp region; i.e., their source could be relatively close to the Earth as is the case with nightside aurora. (3) We find unusual downward moving oxygen ions in the pitch angle range 45-90 degrees which are probably due to upgoing ions being reflected close to the satellite.

EXPERIMENTAL RESULTS ON THE GENERATION OF THE ARTIFICIAL EMISSIONS AS A FUNCTION OF TRANSMITTED POWER.

E.G.Belova, E.V.Pchelkina, A.B.Pashin, W.B.Lyatsky (Polar Geophysical Institute, Apatity 184200, Murmansk region, Russia)
E.Turunen, J.Manninen (Sodankyla Geophysical Observatory, Fin 99600 Sodankyla, Finland)

The results of the heating experiment carried out on November 28, 1995 at EISCAT Heating Facility near Tromso, Norway are presented. The heating wave with frequency of 4 MHz was modulated with 925, 1375 and 2375 Hz. For each modulation regime the power sweeping was used with steps of 17%, 25%, 32%, 50%, 67% and 100% of transmitted power. The ionospheric response was received by VLF antenna situated 100 km far from transmitter. We presented the dynamic spectra of the measured signal which show the generation of artificial emissions on the modulation frequencies. We obtained the dependencies of the amplitude of the signal at these frequencies on the radiated power. The dependencies are essentially non-linear. We have a linear growth of the emission amplitude for small values of the power then an increase of the amplitude growth rate and at last a decrease of the growth rate that manifests the saturation effect. These peculiarities were theoretically predicted by Lyatsky et al. (1995). We also obtained the data on generation of the harmonics of the modulation frequency, studied the regularity of their generation and compared the results with theoretical predictions (Pashin and Lyatsky, 1997). The obtained results could be used for diagnostic of the lower ionosphere.

AN INTERESTING DAY, OR, SUPERDARN OBSERVATIONS OF CONVECTION DURING A PERIOD OF SMALL NORTHWARD IMF.

W. A. Bristow, J. M Ruohoniemi, R. A. Greenwald, P. T. Newell (All at: Johns Hopkins Applied Physics Laboratory, laurel, MD 20723; 301-953-5000; email: Bill_Bristow@jhuapl.edu)

The SuperDARN HF Radar Network provides a nearly instantaneous global-scale view of convection in the ionosphere. Estimates of convection velocities are formed by merging line-of-sight measurements from overlapping beams of radar pairs. A new technique for merging the data has been developed that often greatly extends the area over which velocity estimates can be formed. In brief, the line-of-sight velocity estimates are used to constrain an expansion of the electrostatic potential distribution in terms of spherical harmonics.

The new technique has been used to study convection during the period 1600 UT to 1830 UT on January 5, 1996. During this interval, the IMF observed at the WIND satellite was predominantly northward and was of small magnitude. The total field did not exceed 5 nT throughout the period and was usually below 4 nT. The observed convection pattern showed some characteristics that have been predicted for northward IMF conditions, including sunward convection near noon and, during part of the interval, evidence for a four-cell convection pattern. In addition, DMSP particle data show evidence for a polar cap arc located within the pattern. Some important aspects of the observations contradict expectations. These include: strong flow across noon from dusk toward dawn during an interval when the observed IMF B_y was small and negative; a convection pattern that evolved rapidly and continually throughout the period despite relatively steady IMF conditions; and surprisingly large convection velocities for the observed IMF conditions. At times the observed potential exceeded 40 kV and convection velocities were in excess of 800 m/s.

In this talk, the new merging technique will be discussed briefly, the January 5 observations will be presented, and their implications will be discussed.

THE VARIATION OF IONOSPHERIC CONDUCTANCES WITH ELECTRIC FIELD

J. A. Davies and M. Lester (University of Leicester, Leicester, LE1 7RH, UK)

Common programme observations by the EISCAT UHF radar facility in Northern Scandinavia provide the data set on which a statistical study of ionospheric conductances is based. The study concentrates on the variation of Hall and Pedersen conductances in the nightside ionosphere with electric field strength, the latter of which is derived from tristatic F-region velocity observations by the UHF radar. The conductances themselves are derived from alternating code observations between some 90 and 200 km altitude, incorporating, moreover, results from both the IGRF model of the geomagnetic field and the MSIS-86 thermospheric model. In addition, a comparison with substorm phase is made.

Initial Results from the FAST Satellite: Solitary Waves and AKR

R.E. Ergun, C. W. Carlson, J.P. McFadden, C. Chaston, G. T. Delory, W. Peria, F.S. Mozer, M. Temerin, (University of California, Berkeley); R. Elphic (Los Alamos National Laboratory); R. Strangeway (University of California, Los Angeles); D.M. Klumpar, E.G. Shelley, W.K. Peterson (Lockheed Martin Palo Alto Research Laboratory); E. Moebius, L. Kistler (University of New Hampshire); C. Cattell (University of Minnesota); R. Pfaff (Goddard Space Flight Center)

The FAST satellite was recently launched into a high inclination, 4200 km apogee orbit. The mission was designed to make detailed studies of auroral plasma processes with high time resolution field and particle measurements. We present early observations of DC electric field turbulence, VLF emissions, and auroral kilometric radiation (AKR) and the accompanying particle distributions in or near the auroral density cavity. The focus will be on recently discovered large-amplitude, 100 microsecond duration solitary waves and AKR source crossings. The solitary waves appear to have a substantial (~10%) component parallel to the magnetic field and are frequently observed near the auroral density cavity. The estimated size of the structures is such that the electron transit time is on the order of their duration, which implies that the solitary waves may play a substantial role in electron acceleration. The FAST satellite has also made several, 0.5 microsecond resolution AKR wave form captures of two components of E and one component of B in the auroral density cavity. Analysis of these wave form captures shows power in both the Z-mode and X-mode, and occasional bursts of electrostatic emissions. The electron distributions are depleted below ~1 keV (typical) in energy, creating both a perpendicular and parallel instability. We also describe the capabilities of the FAST Fields instrument.

STRUCTURE OF AURORAL PLASMA PRECIPITATION REGION, LARGE-SCALE CONVECTION, FIELD-ALIGNED CURRENTS AT MID- AND LOW-ALTITUDES AND MAPPING OF CORRESPONDING BOUNDARIES TO THE MAGNETOSPHERE

Y.I.Feldstein, L.I.Gromova (IZMIRAN, 142092 Troitsk, Moscow Region, Russia)
J.Woch (Max-Planck-Inst. für Aeronomie, D-37189 Katlenburg-Lindau, Germany)
L.Blomberg and G.Marklund (Alfven Laboratory, S-100 44 Stockholm, Sweden)
C.-I.Meng and T.A.Potemra (APL/JHU, Laurel, MD 20707,USA)
I.Sandahl (Swedish Institute of Space Physics, , S-981 28 Kiruna, Sweden)
I.I.Alexeev and V.V.Kalegaev (Moscow State University, 119899 Moscow, Russia)

Structure of auroral energy plasma precipitation offered by Newell et al. (1996) for nearmidnight sector is widened to cover MLT dawn and dusk sectors based on Viking and DMSP satellite measurements. The boundaries of characteristic structural domains were determined using electron and ion spectra relying on physical features of plasma streams in corresponding regions. Viking's measurements of the electric field components were used for determination of the convection direction and the CRB (Convection Reversal Boundary) location, as well as relationship among the convection, plasma domain structure and large-scale field-aligned currents. The boundaries dynamics is discussed in connection with magnetospheric substorms phases and the interplanetary magnetic field components variations. Plasma regions boundaries and the CRB are mapped to the magnetosphere equatorial plane using the geomagnetic field paraboloid model allowing for various sources of magnetic fields in the magnetosphere.

FIRST RESULTS FROM THE EISCAT SVALBARD RADAR

N. G. J. Gazey, I. W. McCrea, M. Lockwood, M. Grande, B. J. Kellett, M. K. Carter and C. H. Perry (Rutherford Appleton Laboratory, Chilton, Oxfordshire, England OX11 0QX)

We present new data from the EISCAT Svalbard radar (ESR) together with results from the CAMMICE (ion) and CEPPAD (electron) instruments on POLAR. POLAR's orbit cuts meridionally through the high-latitude magnetosphere and so the satellite can measure changes at or near the cusp while the ESR measures the properties of the high-latitude ionosphere. We concentrate on a set of ESR runs which have been coordinated so as to happen in conjunction with passes of POLAR near to the noon meridian.

DP1 AND DP2 CURRENT SYSTEMS OF THE MAGNETIC SUBSTORM CALCULATING WITH GEOMAGNETIC STEP DATA BASE

S.A. Golyshev, A.E. Levitin, V.O.Papitashvili (IZMIRAN, 142092 Troitsk, Moscow Region, Russia)

On the base a one minute geomagnetic data (STEP data base) DP2 and DP1 current systems are detached in the magnetic substorm period. At that current system DP1 does not connect with "current wedge" and may be represented as sum two DP2 systems. The first of them is the classic two-cell current system, connected with the acceleration of the magnetospheric convection in the substorm period. Second DP2 system is the new current system, that consists of the two-cell current system too, but currents in this cells have directions opposite to those in the cells produced classic DP2. We think that currents in new current system are connected with processes of magnetospheric convection hamper near maximum of magnetic bay. The problem of detachment current systems in substorm period with geomagnetic data and modern models of substorm current systems are discussed also.

Accelerated electron beam precipitations in and around the cusp/cleft region.

Marina Goncharova, W.Lyatsky, and V.Kriviliov (Polar Geophysical Institute, Apatity, Russia)
Patrick Newell and David Sibeck (APL/JHU, Laurel, Maryland, USA)

From the DMSP satellite measurements for several months, 1984, discrete accelerated electron beam precipitations in the cusp/cleft region are investigated. These events are observed not for the negative IMF Bz values only, but for positive Bz (by small By) values as well, i.e., when the magnetic reconnection on the lobe magnetic field lines is expected. These auroral electron precipitations (associated perhaps with the PMAFs) appear immediately posterior to the equatorial boundary of the LLBL or even that of the BPS (as was pointed out earlier by Newell et al., 1991). They are often embedded in the diffuse background dayside PS or BPS electron precipitations. The spike structure in the electron precipitations being observed together with the plasmasheet electron population indicates that some part of the PMAFs may appear on closed field lines. Very important result is that the polar boundary of plasmasheet plasma population show the energy drop which is not sharp as expected for the magnetic field reconnection but smooth within a finite latitude range. Perhaps this plasma remains on closed but increasing-in-length magnetic field lines. Sometimes such smooth energy transition in fractions of PS-like electron population down to energies typical for cusp is observed to repeat along the satellite trajectory, being distanced rather far in latitude that is also hard to explain in terms of reconnection. A possible explanation is the most equatorial of the events may be placed on closed magnetic field lines, and may be formed due to some another mechanism than bursty reconnection at the dayside magnetopause.

Two possible causes for the magnetosheath ion energy dispersion injections in the cusp/cleft region.

Marina Goncharova, W.Lyatsky, and V.Kriviliov (Polar Geophysical Institute, Apatity, Russia)
Patrick Newell and David Sibeck (APL/JHU, Laurel, Maryland, USA)

Two possible causes for the ion energy dispersion injections in the cusp/cleft region may be proposed. The first one is a shift of magnetosheath ions penetrating through the cusp/cleft region inside the magnetosphere, due to the magnetospheric convection while the precipitating particles move from the magnetopause to the ionosphere. This cause is usually considered when modelling the velocity filter effect. The second cause is a consequence of the cusp displacement due to the changes in the solar wind dynamic pressure and/or the IMF Bz and By component variations. The magnetic field lines for this case may be considered as being fixed in the ionosphere. The contributions of both these mechanisms would have approximately the same order of magnitude, but the former is proportional to the product of the solar wind velocity and the IMF Bz or By components, whereas the latter is proportional rather to the time derivative of this product value. The investigations of the ion energy dispersion injections in the DMSP data show that both mechanisms may operate. Some results of numerical simulation for the ion energy dispersion injections into the cusp/cleft region are also presented.

EQUIVALENT IONOSPHERIC CURRENTS AT THE HIGH LATITUDES CONTROLLED BY IMF AND ITS USE FOR ANALYSIS OF SATELLITE AND RADAR DATA

L.I.Gromova, A.E.Levitin, V.O.Papitashvili, Y.I. Feldstein (IZMIRAN, 142092 Troitsk, Moscow Region, Russia)

The regression analysis technique permits us to relate quantitatively the ground-based magnetic field hourly values in Northern and Southern hemispheres with the IMF and SW parameters on the same time-scale. In this work we find out the time shift (T) between IMF(t) and equivalent current I(t+T), that gives the good correlation between model calculation and experiment for minute time-scale. The possibility of this model calculations for analysis of satellite data (the electric field, the convection) when a satellite crosses the high latitudes for considerably a long time period (as Viking) when Bz and By IMF components change its direction are discussed. The problem of the comparison of radar and satellite data with different modern models of electric field or convection are discussed also.

EVACUATION OF THE TOPSIDE IONOSPHERE BY MOVING AURORAL ARCS

G. Haerendel (Max-Planck-Institut für extraterrestrische Physik, Giessenbachstraße, 85740 Garching, Germany)

The relation of density depletions in the upper ionosphere and auroral arcs is meanwhile a well established fact. Much evidence has been added with the Swedish-German FREJA satellite. The slow proper motion of auroral arcs with respect to the ionosphere of typically 100 to 200 m/s leads to a progressive evacuation of the upper ionosphere through the interaction of the accelerating electrostatic potentials with the cool ionospheric plasma. At the leading edge, highly field-aligned, downward-directed electron beams with a wide range of parallel energies are generated and O^+, He^+ and H^+ ions are injected upward into the magnetosphere. The narrowness of this edge effect reflects the ratio of the evacuation and auroral propagation time-scales. The physics underlying auroral arc propagation and ionospheric evacuation are to be discussed.

SUBSTORM ACTIVITY IN AN IONOSPHERE-MAGNETOSPHERE COUPLING SIMULATION

P. Janhunen (Finnish Meteorological Institute/Geophysical Research, P.O.B. 503, FIN-00101, Helsinki, Finland)

Our ionosphere-magnetosphere coupling simulation (GUMICS) is composed of a global magnetohydrodynamic (MHD) magnetosphere and an electrostatic ionosphere which are coupled through field-aligned currents, electric fields and electron precipitation. The GUMICS model differs from other global MHD models by its higher near-Earth resolution and more accurate and sophisticated ionospheric part. Achieving high resolution in the near-Earth region is difficult because the Alfven speed is very high there and, consequently, a very small time step must be used. GUMICS fights agains this problem by using a hierarchically refined Cartesian grid, a Godunov-type finite volume method, and subcycling in time stepping.

The oral part of the talk will contain a general introduction to the model as well as some recent results concerning the closure of Region-1 and Region-2 current systems and substorm onsets. In the video presentation we will show how the ionospheric conductivity and convection patterns develop in varying IMF conditions. We will also show various 2D intersections of the magnetosphere when substorm activity takes place in the model.

SUBAURORAL ELECTRIC FIELDS OBSERVED BY THE FREJA SATELLITE, A STATISTICAL STUDY

T. Karlsson, G. T. Marklund and L. G. Blomberg (Royal Institute of Technology, Division of Plasma Physics, S-100 44 Stockholm, Sweden)
A. Mälkki (Finnish Meteorological Institute, Geophysical Research, P.O.Box 503, FIN-00101 Helsinki, Finland)

Over 12 months of Freja electric field data have been scanned for subauroral electric fields (SAEF) to enable a comprehensive study of their ionospheric signatures. SAEF are encountered at magnetic local times from 18 to 02 with a large majority of the SAEF encountered at a time slightly pre-midnight (22 - 23 MLT), where also the strength of the subauroral electric field is the largest. The data confirm that SAEF occur during the substorm recovery phase, but also show that SAEF occur earlier during recovery, when located close to 22 MLT than at other local times. The dependence on season and geomagnetic activity is studied, and it is found that the SAEF are more commonly observed at times of high activity. The SAEF are then also generally stronger, except close to winter solstice, when strong electric fields are observed during low activity. The potentials associated with the SAEF and the relation to IMF B_y are also studied.
The observations are discussed in context with substorm-related field-aligned currents and the mid-latitude trough. These new observations can be used to test and extend our current knowledge of subauroral electric fields. We show that one of the proposed production mechanisms can be extended and refined, so that it can account for the current observations.

SC-TRIGGERED POLAR CAP PULSATIONS AND THEIR SOURCES IN THE MAGNETOSPHERE

E.A.Kasatkina and O.I.Shumilov (High-latitude Geophysical Lab. of St.Petersburg Filial of IZMIRAN, Apatity, Russia)
O.M.Raspopov (St.Petersburg Filial of IZMIRAN, St.Petersburg, Russia)
A.V.Frank-Kamenetsky (Arctic and Antarctic Reseaech Institute, St.Petersburg, Russia)

SC-associated geomagnetic pulsations have been observed on magnetometer records from Mirny (L=18.5) and Heiss Island (L=14.75) high-latitude stations. These pulsations have dominant periods (20-50 sec) and time delays from the SC onsets ranging between 4 and 22 min. The pulsations were accompanied by absorption events that are quite different from sudden commencement absorption (SCA) and auroral absorption (AA) events observed at high latitudes earlier. Analysis has shown that the geomagnetic pulsation occurrence is controlled by solar wind speed and initiated by Kelvin-Helmholtz instability (KHI). Possible sources of geomagnetic pulsations and their locations in the magnetosphere have been discussed.

COHERENT RADAR ESTIMATES FROM STARE AND SABRE OF HIGH LATITUDE BIRKELAND CURRENTS

M. J. Kosch, T. Hagfors and E. Nielsen (Max-Planck-Institut für Aeronomie, D-37189 Katlenburg-Lindau, Germany)

Two bistatic VHF radar systems, STARE and SABRE, have been employed to estimate ionospheric electric fields and their divergence in the geographic latitude range 63.4 - 72.6^0 (magnetic latitude 60.9 - 70.1^0) over Scandinavia. Over 170 days of good backscatter from all four radars have been analysed during the period 1982 to 1986 to calculate the average ionospheric divergence electric field versus latitude and time. An AE-dependant empirical model of the ionospheric height-integrated Pedersen conductivity was used to calculate the average magnetic field-aligned currents associated with the divergent electric fields for the entire data set. No attempt has been made to include the field-aligned currents associated with gradients in the conductivity. Statistical Birkeland current estimates are presented as function of the Kp and Ae indices as well as various orientations of the IMF.

FINITE LARMOUR RADIUS CONVECTION INSTABILITY IN THE PLASMA SHEET

A.E.Kozlovsky and W.B.Lyatsky
(Polar Geophysical Institute, Apatity, Russia)

It is shown that the violation of freezing-in condition for the plasma sheet ions, when the Larmour radius of ions is greater than spatial scale of the disturbance, leads to an instability of the magnetospheric convection and its separation into narrow convection jets with width of order of few kilometres at the ionosphere level. The instability appears in those areas of the plasma sheet, where containing of hot ions in unite magnetic flux tube varies with the distance from the Earth, that take place at the inner and outer boundaries of the plasma sheet. The instability has high growth rate (characteristic growth time is of order of ten seconds). In the area of the westward ionospheric electric jet, the developed structures are stretched at small angle to the ionospheric electric current, i.e. approximately along the auroral oval.

IONOSPHERIC PLASMA CONVECTION, ELECTRIC FIELDS AND FIELD-ALIGNED CURRENTS DERIVED FROM THE SUPERDARN RADAR OBSERVATIONS AND PREDICTED BY THE IZMIRAN ELECTRODYNAMIC MODEL (IZMEM)

A V Kustov and G J Sofko (ISAS, U of Saskatchevan, Saskatun, Canada)
R A Greenwald and J M Ruohoniemi (APL/JHU, Laurel, Maryland, USA)
Y I Feldstein, L I Gromova, A E Levitin, V.O.Papitashvili, B A Belov (IZMIRAN, 142092 Troitsk, Moscow Region, Russia)

IZMEM is a potentially very useful tool for forecasting of the electric field and plasma convection patterns and the field-aligned current distributions over the high latitude ionosphere. The SuperDARN HF radar network provides ample opportunities for comprehensive comparisons of measured ionospheric plasma drifts with the modeled electric fields (i.e., 2-D plasma convection) and field-aligned currents. Several events under the relatively stable and unstable IMF conditions are investigated and discussed. Situations with IMF $B_z>0$ and $B_z<0$ are considered. Correlation coefficients for the SuperDARN/ IZMEM comparisons for both the magnitude and direction of the fields are found to be of the order of 0.7. The IZMEM predictions of location, direction and magnitude of the field-aligned currents are also in good agreement with the SuperDARN observations. As expected, the IZMEM model is less reliable in forecasting of localized ionospheric plasma inhomogeneities, especially during the non-stationary IMF conditions.

THE ELECTRIC FIELD RESPONSE TO SUBSTORM PROCESSES

R. V. Lewis, M. P. Freeman and A. S. Rodger (British Antarctic Survey, Cambridge CB3 0ET, UK)

In contrast to its optical and magnetic field counterparts, the behaviour of the substorm electric field has received less attention. However, the new generation of HF coherent radars known as SuperDARN are now beginning to address this topic with their ability to provide excellent spatial coverage of ionospheric flow patterns at high temporal resolution. In this paper, we will investigate, using a number of different examples, the behaviour of the electric field during both the substorm cycle and at various locations with respect to the substorm current wedge. We will show that by combining the radar observations with those from other ground-based instrumentation and various spacecraft of the ISTP era, we are able to gain new insight into the night-side high-latitude ionosphere and magnetosphere.

IONOSPHERIC SIGNATURES OF GEOMAGNETIC PULSATIONS

Yu.V.Lipko, G.A.Zherebtsov, B.O Vugmeister, R.A.Rakhmatulin, L.A Leonovich and I.V Tabanakov (Institute of Solar-Terrestrial Physics SD RAS, Irkutsk, 664033, P.O Box 4026, Russia)

The objective of this work was to investigate fine structure of ionospheric irregularities with high time resolution at times of observations of geomagnetic pulsations of different types in the auroral zone To implement this program, a special experiment on simultaneous recording of geomagnetic pulsations and frueqency Doppler shifts (FDS) of the ionosphere-reflected radio signal was organized at station Norilsk ($\phi = 64.2$; $\lambda = 160$ 4). It was found that the appearance of irregular geomagnetic Pi2 pulsations and regular pulsations with periods of 60-150 s is accompanied by concurrent changes in the FDS signal envelope The basic frequency of geomagnetic pulsations and FDS variations coincides very closely. The research done in this work leads us to draw the following conclusions The Pi2 pulsation amplitude is controlled by the ionospheric Es-layer, while the Pc5 pulsation amplitude is governed by the F2-layer

RELATIONS BETWEEN BIRKELAND CURRENTS, AURORAL FORMS, AND PRECIPITATING ELECTRONS AS OBSERVED BY FREJA

H. Lühr and M. Rother (GeoForschungsZentrum Potsdam, Germany)
W. Guo and D.J. McEwen (University of Saskatchewan, Canada)
J.H. Clemmons (NASA Goddard Space Flight Center, Greenbelt, Maryland)

The Swedish-German satellite Freja traversed auroral latitudes in the North American sector. During the winter 1993-94 a correlated ground/ satellite campaign was conducted utilizing all-sky cameras at Rabbit Lake and LaRonge (both Canada).
In more than 10 cases good auroral images could be obtained during Freja passes. From the Freja magnetometer and electron spectrometer (TESP) we deduce the Birkeland currents and electron energies and fluxes, respectively. In general the upward field-aligned currents and precipitating electrons correspond well with the optical forms while the downward FACs can be found on either side of the auroral arc. The exact relationship between theses three quantities will be discussed for several examples.

ON THE CONNECTION BETWEEN THE PATCHES OF IONISATION AND THE AURORAL FORMS IN THE SOUTHERN POLAR CAP

L.N.Makarova and A.V. Shirochkov (Arctic and Antarctic Res.Institute, Saint-Petersburg, 199397, Russia)

Detailed analysis of the vertical ionograms at antarctic station Vostok located deeply inside the Southern polar cap allows to select the type of ionogram corresponding to the "patch" of ionization whose origin and properties are how vividly discussed in the literature. Prominent features of such ionograms are the high electron density in the F-layer located at great heights (up to 400 km). The occurrence of the patches above Vostok was compared with simultaneous observations of the auroral forms recorded at Vostok by means of all-sky camera in 1981-1986. It was found that all patches occurrences on the dayside were accompanied by the auroral forms in the zenith above Vostok. The huge amount of similar data collected for three decades of observations allows to make thorough study of the patches dynamic in the Southern polar cap.

FACTORS INFLUENCING THE CUSP POSITION

Yu.P.Maltsev, A.A.Ostapenko
(Polar Geophysical Institute, Apatity, 184200, Russia)

An empirical magnetic field model has been composed for the dayside magnetosphere. Several thousand field measurements from the data set of Fairfield *et al.* have been used. The model depends on five parameters: *Dst* and *Kp*-indices, solar wind dynamic pressure, IMF vertical component, and geodipole tilt angle. Relative influence of each parameter on the dayside polar cusp latitude has been studied. The cusp position appears to be affected mainly by the tilt angle and *Dst*-index. Influence of the southward IMF on the cusp latitude is more significant than that of the northward one.

FREJA ELECTRIC FIELD OBSERVATIONS ASSOCIATED WITH LARGE-SCALE AURORAL SPIRALS

G. T. Marklund and T. Karlsson, Division of Plasma Physics, Alfvén Laboratory, The Royal Institute of Technology, Stockholm, Sweden

The characteristics of the fine scale electric field associated with the westward travelling surge and large-scale auroral spirals are investigated using high-resolution electric field, magnetic field, particle and UV-imager observations from four eveningside auroral oval crossings by the Freja satellite. One pass went directly through the head of a westward travelling surge whereas the other passes were adjacent to auroral spiral formations, one poleward of and one equatorward of such forms and one through the multiple arc region near the surge front. The ambient electric field was found to intensify in the direction towards the spiral head confirming previous findings that the spiral head is associated with negative space charge and intense upward field-aligned currents. In the surge head narrowly structured, intense (up to 700 mV/m) and mostly converging electric fields associated with intense electron precipitation and balanced field-aligned currents are seen near the edge. The results suggest that a significant part of the upward surge current is closed by distributed downward field-aligned currents from the near surroundings. The surge electric field is much more intense than previously observed or anticipated at these altitudes with characteristics rather similar to those observed in the auroral acceleration region. Since the particle data indicate that most of the acceleration takes place above Freja altitudes it seems as if Freja traversed the lower part of the auroral acceleration region above the surge.

EFFECTS OF PRECIPITATING PARTICLES AND HEAT FLUXES IN THE CUSP IONOSPHERE

V.S.Mingalev and G.I.Mingaleva (Polar Geophysical Institute, Apatity 184200, Russia)

The numerical model of the polar ionosphere is applied to study how latitudinal variations of average characteristics of precipitating electrons and protons influence on the large-scale irregularity structure of the high-latitude F-layer in the cusp region. The role of heat fluxes,flowing into the ionosphere from above,on the spatial structure and thermal regime of the cusp ionosphere is investigated, too. Statistical models of auroral electron and proton precipitations, based on satellites measurements,is used in our computational study. Some attractive peculiarities of the spatial structure of the cusp ionosphere were found from our study.

NEW STARE IN OPERATION

E.Nielsen (Max planck Institute for Aeronomie, D-37189 Katlenburg-Lindau, Federal Republic of Germany)
R.Pellinen (Finnisch Meteorological Institute, Box 503, Vuorikatu 24, SF-00101 Helsinki, Finland)

A modernized STARE (=Scandinavian Twin Auroral Radar Experiment) has recently been taken into operation. In addition to the backscattered power and Doppler velocities measured over a large field of view (160000 km2) with good spatial and temporal resolution, the system now also provides the backscatter power spectra with good resolution in a large area centered on EISCAT (Tromsoe). In addition the system software has been modernised, and permits now more flexibility in the exequted experiments. Furthermore, real time remote access to the stations and to the combined measurements from the stations are planned.

DAYSIDE AURORAL PRECIPITATION ZONES AND BOUNDARY LAYER PLASMAS: RELATIONSHIP WITH IMF CLOCK ANGLE

P.E. Sandholt and A. Egeland (Department of Physics, University of Oslo, Box 1048 BLINDERN, N-0316 OSLO, NORWAY)

A classification scheme of the different dayside auroral precipitation zones as a function of IMF clock angle is presented.

Transitions between different auroral configurations corresponding to changes in clock angle are documented.

The correspondence between these auroral forms and the magnetospheric plasma sources, such as the dayside extension of the plasma sheet, the low-latitude boundary layer, the exterior cusp (cusp proper) and the plasma mantle is discussed.

COMPARISON OF RADAR AND MAGNETOMETER CUSP SIGNATURES

D.A. Neudegg, B.J. Fraser, F.W. Menk (University of Newcastle, NSW, Australia)
A.S. Rodger (British Antarctic Survey, High Cross, Cambridge, UK)
M.J. Engebretson (Augsburg College, Minneapolis, Minnesota, USA)

The cusp projection onto the ionosphere measured by the PACE radar at Halley Bay and Pc1-2 noise from South Pole induction magnetometer, associated with cusp passage at high latitude stations, have been intercalibrated. A latitudinal grid about South Pole was constructed to account for the field of view of the magnetometer due to the integration of contributions from current sytems. A wider grid was considered to account for ducting of the pulsations in the F2 waveguide from a source outside of the magnetometer field of view. For days selected where the radar observed a cusp signature both within the South Pole grid cell and outside of it, magnetometer spectrograms were examined. Signature coincidence combinations were determined for one hour sections. Counting statistics were performed to assess the relative occurrences of cases for and against the hypothesis that the signatures are coincident. Binary sequences representing signature occurrence were constructed for the two instruments. Statistical levels of coincidence for the two sequences were assessed by rank correlation tests. Randomness in the sequence of signature coincidences was assessed using nonparametric runs tests. The two signatures are shown to be significantly correlated. Case studies illustrate the relation between pulsations associated with high latitude projections and their positions inferred from the location of the PACE cusp signature.

THE RESPONSE OF TANGENTIAL COMPONENT OF THE IONOSPHERIC ELECTRIC FIELD ON AURORAL ARC BRIGHTENING DURING PSEUDOBREAKUPS

V. Safargaleev, W. Lyatsky (Polar geophysical institute, Apatity, Russia, 184200)
N.Gazey (EISCAT group, Space Science Department, Rutherford Appleton Laboratory, Chilton, Oxfordshire, OX11 0QX, England),
P. Smith (Space Physics Group University of Sussex, Brighton E Sussex BN1 9QH)

The observations of the temporal variations of azimuthal component of ionospheric electric field in the vicinity of an auroral arc before substorm onset on February 18, 1993 are presented. The electric field measurements were supplied by tri-static UHF facility (Tromso, Sodankyla and Kiruna), the auroras were registered by TV camera in Tromso and all-sky camera in Loparskaya. Few minutes before the auroral breakup, the preexisting poleward arc began to drift slowly toward the Tromso magnetic zenith where the measurement of electric field was carried out. The arc was oriented almost along the geographic meridian. There were three short-lived activations of the arc during the movement (pseudobreakups). It was found that every time the increase of the arc luminosity was accompanied by the decrease of the azimuthal component of the ionospheric electric field. It was found also that the arc fading before the last pseudobreakup was accompanied by the increase of the eastward electric field. The observed response of the electric field on the auroral arc brightness testifies that the appearance of a narrow strip of the enhanced conductivity in the ionosphere may lead to the vanishing of the tangential component of the electric field in the vicinity.

ENERGETIC PARTICLE BEAMS AT ABOUT 3 R_E ABOVE THE HIGH-LATITUDE POLAR CAP

V. A. Stepanov, F. K. Shuiskaya, A. K. Kuzmin and A. A. Skalsky (Space Research Institute of RAS, Space Plasma Physics Department, Profsoyuznaya str. 84/32, 117810, Moscow, Russia)

The SKA-3 set of particle analyzers installed onboard the INTERBALL-2 (Auroral Probe) allows to measure spectra and anisotropy of electrons and ions (30 eV - 15 keV), time-of-flight energy and masses of H^+, He^+ and O^+ ions (30 - 600 keV), and energetic electrons (30 - 500 keV). Preliminary results of these measurements are presented. A novel feature are observations at altitudes about 3 R_E of powerful (up to $10^{-2} erg/cm^2 \cdot s \cdot sr$) narrow field-aligned particle beams in the energy range $\approx$15 - 30 keV at the edge, and inside, the Northern polar cap (if its boundary is defined from the drop of low energy ion intensities). The cases found are compared with the preliminary data of other onboard instruments of the INTERBALL–2 and with some simultaneous data from the INTERBALL–1 (including nearly magnetically conjugate data in the near-Earth tail), and also with ground-based data.

PLASMA AND FIELD-ALIGNED CURRENT STRATIFICATION. THEORY AND OBSERVATIONS.

Marina Stepanova and **Marina Stepanova** (Departamento de Fisica, Universidad de Santiago de Chile, Santiago, Chile)
Elizavieta E. Antonova (Moscow State University, Moscow, Russia)

Stratification of upward field-aligned current was studied using the Intercosmos-Bulgaria-1300 satellite data base. 22 events of multiple large-scale inverted V structures have been identified. A possible mechanism of plasma stratification within the inner plasma sheet is discussed. It is suggested that plasma pressure is isoptropic and particle motion is unmagnetized for the considered structures spatial scales. The solution of the magnetosphere-ionosphere interaction problem shows that upward field-aligned current may split into separate structures. The number of structures formed is determined by a parameter which depends on upward field-aligned current density, field-aligned current band width, hot magnetospheric ion temperature,and heigh-integrated Pedersen ionospheric conductivity. It is shown that obtained parameters are in accordance with predicted, and that the hot stratification plasma mechanism describes well the number of observed structures. Thus type of rearch will be persued using the INTERBALL data.

CUTLASS OBSERVATIONS OF DAYSIDE HIGH SPEED ANTISUNWARD FLOW BURSTS CONTAINING BOTH POLEWARD AND EQUATORWARD PROPAGATING FEATURES

J. R. Taylor, T. K. Yeoman, M. Lester, and S. W. H. Cowley (University of Leicester, Leicester, LE1 7RH, UK)

Dayside ionospheric convection during the interval 1000-1200 UT on 13 March 1996 is studied employing CUTLASS-Finland HF radar data. The radar was operating a special 3 min scan mode during which beam 7 was sampled 9 times, optimising spatial and temporal resolution. During the interval the IMF was variable but mainly contained a southward component. The radar field-of-view was in the early afternoon magnetic local time sector. Range-time-velocity plots exhibited bursts of high speed antisunward flow. These bursts appeared in patches which appeared to move poleward at latitudes > 70° and equatorward at lower latitudes. The poleward moving flow bursts during the first 90 min of the interval are similar to features which have previously been identified as flux transfer events in other HF radar studies. The source of the equatorward moving features is less clear. We attempt to discuss the origin of these flow burst in terms of existing magnetospheric models.

THE SCIENTIFIC PROGRAMME OF THE EISCAT SVALBARD RADAR

P.J.S. Williams (University of Wales Aberystwyth, Ceredigion SY23 4LU, Wales, U.K.)

The inauguration of an incoherent scatter radar on Svalbard must be seen in co-ordination with the existing EISCAT radars and the developing network of other ground-based instrument in the area. The common modes of the new radar will be similar to those established at EISCAT and it is likely they will include continuous observations along the field line - either covering the E- and F-regions or the topside, a rapid scan through 4 directions, a latitude scan, and observations at low elevation towards the south or towards the north. Various combinations of the common programmes carried out by the mainland and Svalbard radars must be considered: by providing simultaneous observations at different latitudes, the value of the full system will be more than the sum of its parts. The scientific potential will be further enhanced by data from SuperDARN, imaging riometers, magnetometers and optical instruments. Topics covered will include : Dayside Auroral and Plasma-Flow Transients; the Cleft Ion Fountain; the Polar Cap Convection for southward and northward directions of the Interplanetary Magnetic Field; Polar Cap Precipitation; the Polar Wind; Patches, Blobs and Irregularities; Non-thermal Plasmas; Thermospheric Response to IMF; Tidal Modes at High Latitude; and the Generation and Propagation of Atmospheric Gravity Waves. If the problems of ground clutter are overcome, the list will be extended to include Coupling Processes between the Mesosphere and the Lower Thermosphere.

HIGH-LATITUDE HF DOPPLER OBSERVATIONS OF ULF WAVES WITH LARGE SPATIAL SCALE SIZES

D. M. Wright and T. K. Yeoman (University of Leicester, Leicester, LE1 7RH, UK)

A quantitative study of observations of the ionospheric signatures of magnetospheric ultra low frequency (ULF) waves by a high-latitude (geographic: 69.6°N 19.2°E) high frequency (HF) Doppler sounder has been undertaken. The signatures, which are clearly correlated with pulsations in ground magnetometer data exhibit periods in the range 100-400 s and have azimuthal wave numbers in the range 3-8. In addition, phase information provided by O- and X-mode Doppler data support the view that these are associated with field line resonances having large azimuthal scale sizes. The relative phases between the signatures in the Doppler and ground magnetometer data are compared with a model for the generation of Doppler signatures from incident ULF waves. The outcome suggests that the dominant mechanism involved is the vertical component of an ExB bulk motion of the local plasma caused by the electric field perturbation of the ULF wave.

ST13 Ionosphere-thermosphere-mesosphere coupling

Convener: Jarvis, M.J.
Co-Convener: Aylward, A.D.

LARGE SCALE ATMOSPHERIC GRAVITY WAVES AND ASSOCIATED TRAVELLING IONOSPHERIC DISTURBANCES MODELLED WITH A COUPLED THERMOSPHERE - IONOSPHERE - PLASMASPHERE GLOBAL MODEL.

R. Balthazor and R. Moffett (Upper Atmosphere Modelling Group, University of Sheffield, Sheffield)

Simulating local heating of the auroral thermosphere via Lorentz forcing and Joule heating in a self-consistent global coupled atmospheric model produced families of large scale atmospheric gravity waves (AGWs) travelling preferentially meridionally, both poleward and equatorward. Heating at conjugate magnetic latitudes resulted in interference of the equatorial-travelling AGWs at the magnetic equator, but partial decoupling of the associated travelling ionospheric disturbances (TIDs) from the AGWs. Examination of the neutral-ion wind coupling in the regime of low dip angle explains the complex behaviour of the observable TIDs. Poleward travelling AGWs were ducted over the polar cap by a combination of neutral winds and Coriolis effects, with the behaviour depending strongly on the sector where the local heating was applied. Modelling AGWs were observed to travel both meridionally over and zonally around the polar cap and in some cases reversed the classical leading-peak, trailing-trough structure of the AGW in a fixed pressure frame.

ESTIMATION OF THE O^+-O COLLISION FREQUENCY FROM COINCIDENT RADAR AND FABRY-PEROT OBSERVATIONS AT MILLSTONE HILL

M. J. Buonsanto, D. P. Sipler, J. M. Holt, and J. E. Salah
Massachusetts Institute of Technology, Haystack Observatory, Westford, MA 01886

The formula for the O^+-O momentum transfer collision frequency has been uncertain due to a discrepancy between results of theoretical calculations and some of the joint radar/optical studies [Salah, 1993]. Calculations suggest a multiplicative factor F=1.2-1.3 times the formula derived by Dalgarno [1964] and Banks [1966], while some of the empirical studies have suggested a multiplicative factor F=1.7. We present results of a new analysis of data from 46 nights of coincident incoherent scatter radar (ISR) and Fabry Perot interferometer (FPI) experiments conducted at Millstone Hill between 1988 and 1995. A complete error analysis is carried out for each derived value of F. This allows us to carry out Monte Carlo simulations which confirm that random errors lead to an increase in the mean value of F, and which provide us with an unbiased result, $F = 1.2 \pm 0.2$. However, this result was obtained from an analysis which neglected vertical neutral winds, about which we have little information. The most likely effect of these winds would be an increase in the value of F, so that our best estimate from this study is $F = 1.4 \pm 0.3$, slightly larger than, but still consistent with theoretical calculations.

ION-NEUTRAL DYNAMICS INVESTIGATIONS: STUDIES OF THE O-O+ COLLISION PARAMETER

C. J. Davis (Rutherford Appleton Laboratory, Chilton, Oxon OX11 0QX, UK)
A. D. Aylward (Atmospheric Physics Laboratory, Department of Physics and Astronomy, University College London, 67-73 Riding House Street,London W1P 7PP)

Joint studies with ground-based Fabry-Perot Interferometers (FPIs - measuring the OI airglow emission from around 240km altitude) and the EISCAT incoherent scatter radar, are made to investigate the dynamics of the interactions between ions and neutrals in the upper atmosphere. In recent years the value of the collision cross-section for the O-O+ collision has come under scrutiny. Several methods are theoretically possible for deriving this from comparisons between radar and FPI measurements. We examine a number of these and estimate how accurate they could be expected to be. Experiments continue, and new multi-FPI configurations in Northern Scandinavia are discussed in the light of the possible improvements these could offer in the studies of the dynamics of the upper atmosphere.

WIND ADVECTION AND COMPOSITIONAL STRUCTURE IN THE MESOSPHERE-LOWER THERMOSPHERE REGION FROM WINDII/UARS OBSERVATIONS.

V. Fauliot and G. Thuillier (Service d'Aéronomie du CNRS, B.P. 3 Verrières-Le-Buisson Cedex, France)
F. Vial (Laboratoire de Météorologie Dynamique du CNRS, Ecole Polytechnique, 91128 Palaiseau Cedex, France)

The WINDII interferometer on board the Upper Atmosphere Research Satellite measures airglow emissions and winds in the 80-120 km height region. Two years of observations have been used to provide the global scale pattern of the zonal mean meridional wind as a function of latitude and altitude for different seasons. From the continuity equation, we derived the latitude-height distribution of zonal mean vertical wind. This allows to determine horizontal and vertical advections experienced by the major constituants in this region. The latitudinal-height structure of the advection regime is then related to that of the measured emission rate of several lines. This allow to investigate the role of transport in compositional mixing and discuss the global distribution and characteristices of natural emissions such as those originating from O, O_2 and OH.

UPPER ATMOSPHERE TIDAL OSCILLATIONS DUE TO LATENT HEAT RELEASE IN THE TROPICAL TROPOSPHERE

J. M. Forbes (Department of Aerospace Engineering Sciences, Campus Box 429, University of Colorado, Boulder, CO 80309-0429, USA)
M. E. Hagan (High Altitude Observatory, National Center for Atmospheric Research, P.O. Box 3000, Boulder, CO 80307 USA)
K. Hamilton (Geophysical Fluid Dynamics Laboratory/NOAA, Princeton University, Princeton, New Jersey USA)

Latent heat release associated with tropical deep convective activity is investigated as a source for migrating (sun-synchronous) diurnal and semidiurnal tidal oscillations in the 80-150 km height region. Satellite-based cloud brightness temperature measurements made between 1988 and 1994 and averaged into 3-hour bins are used to determine the annual- and longitude-average local time distribution of rainfall rate, and hence latent heating, between ±40° latitude. Regional average rainfall rates are shown to be in good agreement with climatological values derived from surface rain gauge data. A global linearized wave model is used to estimate the corresponding atmospheric perturbations in the mesosphere/lower thermosphere (80-150 km) resulting from upward propagating tidal components excited by the latent heating. The annual average migrating diurnal and semidiurnal components achieve velocity and temperature amplitudes of order 10-20 ms^{-1} and 5-10 K, respectively, which represent substantial contributions to the dynamics of the region.

THE LONGITUDINAL EFFECTS IN THE THERMOSPHERE INITIATED BY THE UPWARD PROPAGATING SOLAR MIGRATING TIDES

Karpov I.V., Glushchenko T.A. (WD IZMIRAN, Pobedy av.,41, Kaliningrad, 236017, Russia)

The calculations with using the global numerical model of the thermospheric and ionspheric parameters shown that the upward propagating solar migrating tides from middle atmosphere excite the non-migrating tides in the thermosphere (the tide can be approximated by Aexp(i (nt+mx)), t - UT, x - longitude, A - amplitude, n - frequency of tide in unit 1/day, m -zonal wave number, for the solar migrating tides n equal m, for non-migrating tides n not equal m). Thus, the global distributions of the thermospheric parameters have longitudinal variation that connected with the transformation of the solar tides from the middle atmosphere in the upper atmosphere. In the thermosphere (lower 130 km) the solar migrating tides produces the non-migrating diurnal tide with m=0 and non-migrating semidiurnal tides with m=0, 1, 3. The amplitudes of the non-migrating tides reach 30% from the solar migrating tide amplitude. In the upper thermosphere (upper 200 km) the diurnal non-migrating tides are not excited. The semidiurnal non-migrating tides with m=0, 1 equal to the solar tide in the middle latitudes and exceed the solar tides amplitude in the high latitudes. The mechanisms of the non-migrating tides excitement in the thermosphere are discussed.

THE FORBUSH EFFECTS IN COSMIC RAYS AND SPORADIC WINTER ANOMALY

I. Kozin, B. Turkeeva, I. Fedulina (Institute of ionosphere, Kamenskoe plato, 480068 Almaty, Republic of Kazakstan)

It was assumed that electron concentration in the lower ionosphere in the periods of sporadic winter anomaly (SWA) is influenced by variations of nitric oxide concentration NO and temperature at altitudes of about 90 km. A model experiment showed that an electron concentration increasing during SWA is caused only by increasing of nitric oxide concentration since the upper boundary of cluster ions fall up to altitudes of 72 to 77 km. We suggest new mechanism of SWA formation, in which galactic cosmic rays (GCR) are considered as a source of disturbances. An increasing of GCR fluxes during Forbush decreases results in stratosphere heating by 3-4° C between 12 and 15 km, leads to formation of NO drift directed upwards from stratosphere to mesosphere. An electron concentration is increasing in lower ionosphere and produces the effect of sporadic winter anomaly.

THERMOSPHERIC WIND GENERATION OF DOUBLE -PEAKED SPORADIC E-LAYER

V.S.Mingalev and T.N.Lukicheva (Polar Geophysical Institute, Apatity 184200, Russia)

The existence of double-peaked sporadic E-layers in the high-latitude ionosphere is well known experimental fact. By means of numerical simulations of dynamical coupling between the neutral and ionized atmosphere, we identified the mechanism capable of the generation of the sporadic-E layer, with vertical separation of ions taking place in it. The numerical model of the high-latitude ionosphere is applied to investigate how vertical variations of the thermospheric wind influence on the height structure of the E-region. From our study, it was found that double-peaked sporadic E-layer can arise owing to the horizontal thermospheric wind when the latter is strongly non-homogeneous in the vertical direction.

PLANETARY WAVES IN THE LOWER THERMOSPHERE OBSERVED BY METEOR RADAR

N.J.Mitchell, (Department of Physics, University of Wales, Aberystwyth, Ceredigion, SY 23 3BZ, UK; e-mail: njm@aber.ac.uk), A.G.Beard and P.J.S. Williams
H.G.Muller (School of Engineering and Applied Science, Cranfield University, RMCS Shrivenham, Swindon, SN6 8LA, UK)

Planetary waves are now recognised as being of importance in the dynamical coupling across the MLT region. In this study a meteor radar located near Sheffield has been used to study horizontal winds in the lower thermosphere at 53.5°N, 3.9°W over the period 1992-1994. The data reveal the presence of a diverse spectrum of planetary waves. Except for periods near 2-days, wave activity is found to be concentrated in short bursts, often lasting only a few cycles, and occurring at a range of periods between ~3 and ~10 days. There is a marked seasonal cycle in wave activity with a winter maximum, equinoctial minima and a secondary maximum in summer. Observations of a wave of period near 5 days are compared with those made by HRDI from UARS at similar times.

Excitation Mechanisms of MSTID's

MSTID's (Medium Scale Travelling Ionospheric Disturbances) are propagating density waves in the electron content of the ionosphere, with typical horizontal wavelengths of 100-200 km, periods of 10-30 minutes and horizontal phase speeds in the range 100-300 m/s. MSTID's are the response of the ionosphere to upward propagating gravity waves in the neutral atmosphere. A climatology of ionospheric irregularities obtained from the Westerbork Synthesis Radio Telescope (WSRT) in The Netherlands has been used to derive the gravity wave excitation mechanisms which are relevant for the observed MSTID's. The strong zonal jet stream in the upper stratosphere/lower mesosphere seems to be the most important source. Daily and seasonal variations in the observed MSTID quantities can probably be explained by corresponding variations in the wave-induced turbulence produced by breaking gravity waves of tropospheric origin.

Modelling tides and planetary waves with the Coupled Thermosphere-Ionosphere Model (CTIM)

J.Müller-Wodarg and *A.Aylward* (Atmospheric Physics Laboratory, University College London, 67-73 Riding House Street,London W1P 7PP,UK)

The Coupled Thermosphere-Ionosphere Model (CTIM) of UCL, Sheffield University and SEL (Boulder) simulates self-consistently properties of the thermosphere and ionosphere on a global 3-dimensional grid. With its lower boundary at 80 km the generation of tides and planetary waves propagating upwards from the middle atmosphere is not included intrinsically. Recently, the code has been modified considerably to allow simulation of tides and planetary waves. Parameters at the lower boundary are oscillated externally, using relations from classical tidal theory to define the global profile of perturbations and to ensure self-consistency of parameters. Furthermore, the model's vertical resolution has been improved from one scale height to fractions of a scale height. These changes will be presented and results from simulations are discussed.

SPECTRAL CLASSIFICATION OF THE IONOSPHERIC RADIOBURSTS

Musatenko S.I., Kurochka E.V., Astronomical Observatory of the Kyiv University, Kyiv, 254053, Ukraine
Fomitchev V.V., Markeev A.C., Institute of the Terrestrial Magnetism, Ionosphere and Radio Wave Propagation (IZMIRAN), Troitsk, Moscow Region, 142092, Russia

The spectral classification of the night ionospheric impulsive radiobursts with using measurements on the dynamic spectrograph in the frequency range 90-180 MHz for December 1989 have been carried out. Two basic types of the bursts have been determined. The I-st type is broadband bursts (df>100 MHz), with fast frequency drift (df/dt>300 MHz/s), duration (t) from 0.01 to 0.5 s, density (N) from 1 to 100 per hour, flux (P) from 1.E-21 to 1.E-22 W/ (m2 Hz). Most likely, their source are lightning generation in upper atmosphere. The II-nd type is boundary frequency bursts (f<100 MHz) with inner structure corresponding to the USW station receiving and t from 3 to 45s, N near 1-2 burst per hour, P from 1.E-19 to 1.E-21 W/(m2 Hz). Their are caused by sudden improvement of the radiowave propagation. The both types were connected with the solar flares and sporadic ionospheric layers.

THE INFLUENCE OF THUNDERCLOUD POSITIVE CHARGE DYNAMICS ON THE INITIATION OF POSITIVE DISCHARGES AND UPWARD DISCHARGES

A.L.Pasternak (Kiev State University, Physics Department, pr.Glushkova.6, Kiev-022, Ukraine, E-mail: astdept@astrophys.ups.kiev.ua)

The elecrical structure of a thundercloud can be approximated as an electric dipole. The model of Kuusk [1] represents dynamics of charged region in low ionized plasma for atmospheric conditions. This report examines the possibility of the accumulation of positive charge as a result of the absence of a conducting channel for charge loss such as lightning. The characteristic times of destruction of surplus charge is estimated. For light ions (mobility - 10-4m2/Vsec) this time is equal to 10-50sec. for heavy ions (mobility - 10-7 - 10-8m2/Vsec) - >1hour). The basic role of such a mechanism in the generation of positive and upward discharges to the ionosphere is assumed. Comparison of modelled results with observations show reasonable agreement and provides an explanation for a number of observed features of upward and positive discharges.

VERTICAL ATTENUATION RATE OF ATMOSPHERIC GRAVITY WAVES IN THE AURORAL E AND LOWER-F REGIONS OBSERVED WITH EISCAT

T. Shibata and Y. Sakaide (University of Electro-Communications, Chofu, Tokyo 182, Japan)
R. Fujii (STEL, Nagoya University, Chikusa-ku, Nagoya 464-01, Japan)
K. Schlegel (MPAE, Max-Planck-Str. 1, 37191 Katlenburg-Lindau, Germany)

The vertical structure of AGW (atmospheric gravity wave) associated ionospheric fluctuations in the 100-240 km altitude range has been investigated by making use of the ion temperature data provided by the Tromsø measurements in the EISCAT CP1 observation mode. In order to investigate the fluctuation properties quantitatively, we have derived the fractional variations, dT_i/T_{i0}, of the measured ion temperature by removing the base value from the raw data. The dominant component of dT_i/T_{i0} fluctuation has been identified by carring out the spectrum analysis in each altitude. Maximum entropy method was used to obtain high-resolution power spectra. The power as well as frequency of the dominant spectral component depends on the altitude. From the rate of power variation, we have calculated the effective dissipation rate of AGWs in the vertical direction, with taking acount of the inherent growth of AGW amplitude with height owing to the decrease in background density and pressure in the upward direction. It has been revealed that the essential feature of the vertical variation of wave power can be explained in terms of the energy conservation of AGWs propagating in a dissipative thermosphere.

LATITUDINAL INVESTIGATIONS OF SHORT PERIOD 'WAVELENGTH-PERIOD' TRENDS OBSERVED IN NIGHTGLOW IMAGE DATA

M.J. Taylor (Space Dynamics Laboratory and Physics Department, Utah State University, Logan, UT 84322, USA)
W.R. Pendleton Jr. (Physics Department, Utah State University, Logan, UT 84322, USA)

Over the past two decades radar and lidar observations have provided considerable information on the vertical and horizontal scale sizes of gravity waves propagating through the mesosphere and lower thermosphere (MLT) region. In particular, these measurements have been used to investigate trends in the observed period versus horizontal and vertical wavelength of quasi- monochromatic waves present in the data (which exhibit wave periods ranging from typically a few tens of minutes to several hours). Recently, nightglow image data have become available in sufficient quantities to search for similar trends in MLT wave data but for significantly shorter observed periods (typically <20 min). These measurements are important as short period waves are thought to be responsible for much (~70 %) of the momentum deposition at MLT heights (~80-100 km). In this paper image measurements of ~200 quasi-monochromatic wave events, obtained from several sites ranging in latitude from 2 deg S to 40 deg N, are used to investigate latitudinal variability in the angular distribution and wavelength-period trends. The results are compared with existing radar and lidar measurements to assess more completely the characteristics of gravity waves in the MLT region and to investigate geographic variability in wave generation.

THE SOLAR WIND DYNAMIC PRESSURE AS THE COMMON CAUSE OF DISTURBANCES IN THE HIGH - LATITUDE IONOSPHERE, THERMOSPHERE AND MIDDLE ATMOSPHERE

A.V.Shirochkov, L.N.Makarova (Arctic and Antarctic Research Institute, Saint -Petersburg,199397,Russia)

It is shown that any notable rise of the solar wind dynamic pressure causes the synchronous disturbances in the high-latitude ionosphere, thermosphere and middle atmosphere. We checked this effect on various experimental data: the EISCAT measurements of Ne, Te and Ti; rocket sounding of the polar atmosphere; vertical sounding of the high-latitude ionosphere etc. We have found that the following parameters are proportional to the solar wind dynamic pressure: height of the maximum of ionization in the F - region; height of the stratopause, height of the maximum stratospheric ozone density; temperature of lower mesosphere and upper stratosphere. The effects can be explained in the framework of the modified global electric circuit with the Earth magnetosphere magnetopause as an external element.

ST14/OA27 Global ozone

Convener: Hirschberg, M.-M.
Co-Conveners: Fabian, P.; Krivolutsky, A.A.

DO THE GLOBAL WINTER STRATOSPHERIC WARMINGS INFLUENCE ON THE TOTAL OZONE CONTENT OVER EAST SIBERIAN REGION?

A. Yu. Belinskaya, E. S. Kazimirovsky (Institute of Solar - Terrestrial Physics, Russian Academy of Sciences, P. O. Box 4026, 664033, Irkutsk, Russia)

The East-Siberian region is the area of special interest for the global distribution and temporal variation of ozone due to climatic peculiarities and record low ozone values during some winters. Using daily means of the total ozone during 1979-1992 period and superposed epoch method the role of the global and local winter stratospheric warmings in producing of total ozone deviations from the long - term means is evaluated. The systematic satellite-aboard measurement's database (TOMS, NIMBUS-7) was used for this analysis. The calculations were carried out for Irkutsk (52N, 104E) and for some points along the Irkutsk meridian. We have found that the ozone response intensity and nature depend on the latitude and stratospheric warming type (minor, major, final).

RELATION BETWEEN SURFACE OZONE AND NATURAL DUST TRANSPORT IN THE SOUTH EUROPEAN REGION

P.Bonasoni, CNR - FISBAT Institute, Italy
T.Colombo, Italian Air Force Meteorological Service, Italy
G Tesi, Statistics Department, University of Florence, Italy

The presence of aeolian dust in the atmosphere may play an extremely important role in climatic variations. Recent studies have stressed the influence on climate forcing of mineral aerosol, while others have pointed out the impact the dust has on the alteration of gases becouse dust particles are a good surface for chemical reaction.
Several dust transport events with a high mass concentration were identified at Mt.Cimone (44 N, 10 E, 2165 m asl), a baseline mountain site in the northern Italian Apennine. The synoptic situations and the back trajectory analysis show that transports of dust occurred principally from the Sahara desert. Given its position and elevation this site is particularly suitable for direct sampling during such episodes, before they cross the European Continent. The study reveals that there is a low ozone concentration during these transport phenomena. The relation between the events of Saharan dust transport and their effects on ozone recorded at Mt. Cimone are analysed with the meteorological conditions that gave rise to the transport. Two hypotheses to explain these alteration in ozone concentration are proposed.

VALIDATION OF A THREE-DIMENSIONAL STRATOSPHERIC CHEMISTRY TRANSPORT MODEL

M.M.P. van den Broek and A. Goede (Space Research Organisation of the Netherlands, Utrecht, Netherlands)
A. Bregman and J. Lelieveld (Institute of Marine and Atmospheric Sciences, Utrecht, Netherlands)

A new three-dimensional chemistry transport model is developed. The advection scheme is forced by analyzed meteorological data of the ECMWF. The resolution of the model is 3.75° latitude by 5° longitude, with 19 vertical layers, upto 10 hPa. Chemistry of the lower stratosphere is implemented, including heterogeneous reactions, both on polar stratospheric clouds and on/in liquid aerosol. The chemical continuity equations are solved using Euler Backward Iterative.
A year's run was carried out for 1995, the year in which the SESAME campaign took place. Measured profiles of both long-lived species, such as N_2O and CH_4, and chemically affected species, e.g. O_3 and ClO, are compared to the model results in order to validate the model.

ESTIMATIONS OF THE FUTURE DEVELOPMENT OF THE OZONE LAYER

M. Dameris, V. Grewe (DLR, Institut für Physik der Atmosphäre, Oberpfaffenhofen, D-82230 Weßling, Germany)
Ch. Brühl, J.-U. Grooss (Max-Planck-Institut für Chemie, D-55020 Mainz, Germany)

The coupled dynamic-chemical three-dimensional general circulation model ECHAM/CHEM has been used for future studies to treat problems of global climate change due to anthropogenic emissions under consideration of chemical processes in the troposphere and stratosphere, including photochemical reactions and heterogeneous reactions on sulphate aerosols and polar stratospheric cloudes. Special emphasis is given to possible changes of the ozone layer within the next decades, assuming different background conditions of relevant chemical species. In this paper results of multi-annual integrations with ECHAM/CHEM will be presented and discussed.

OZONE AND OTHER TRACE GAS MEASUREMENTS USING THE TRANS-SIBERIAN RAILROAD; THE TROIKA EXPEDITION 96

C.A.M. Brenninkmeijer, M. Hahn, D.S. Scharffe, M.Maiss, and P.J. Crutzen, Max Planck Institute for Chemistry, Mainz, Germany
N.F. Elansky, S. Golitsyn, B. Belikov, M. Grisenko, and V.M. Sevostyanov Inst. of Atmosph. Phys. and Research Institute of Railtransport, Moscow, Russia

Using a laboratory wagon traveling along the Trans-Siberian railroad, O_3, NO, NO_2, CO, CH_4, SF_6, and black carbon aerosol have been measured, summer 1996. The expedition from Nizhiniy Novgorod (500 km east of Moscow) to Vladivostok (and back to Moscow) has shown that a wealth of boundary layer air data can be obtained without serious contamination problems. The diurnal O_3 cycle peaked generally below 50 ppbv, shows correlations with changes in $J(NO_2)$ and NO_x, and often dropped to a few ppbv at night time. Over the west Siberian lowland CO levels were generally low, reaching levels of only 110 ppbv, however, many sections were of course affected by pollution sources. In east Siberia, between about 7000 to 8000 km from Moscow, an extensive air mass with extremely high CO values of up to about 1 ppmv was crossed in both directions. Forest burning seems to be the most plausible explanation. In stark contrast, CH_4 was relatively low at about 1.85 ppmv over eastern Siberian, compared to 1.95 ppmv over much of the west Siberian lowlands. The most probable source for the excess CH_4 are the extensive and abundant wetlands in western Siberia However the occurrence of many sharp spikes suggests relatively nearby local sources, which would be anthropogenic. Isotopic analysis is in progress to try to identify the respective sources better.

MODELLING THE SEASONAL CYCLE OF OZONE IN HIGH AND MID LATITUDES AND THE IMPACT OF THE NO_X/NO_Y RATIO

C. Brühl and P.J. Crutzen (MPI for Chemistry, Mainz, Germany)

Using a two-dimensional chemical model with and without nudging with HALOE/UARS satellite data it is shown that the minimum in total ozone in summer is mostly due to catalytic destruction by NO_x under polar summer conditions in the altitude region between 20 and 30 km. With that model and with boxmodel studies along high and mid latitude summer trajectories we demonstrate also that there is evidence that the recommended rate constant for the formation of HNO_3 from NO_2+OH is too large.

OBSERVATIONS OF NEAR-ZERO OZONE CONCENTRATIONS IN THE UPPER TROPOSPHERE AT MID-LATITUDES.

W. E. Davies, G. Vaughan, S. Bethan, F. O'Connor (University of Wales, Aberystwyth, UK.),

Measurements by an ozonesonde launched from Aberystwyth (52.4N,-4.1E) in July 1996, into cirrus ahead of a warm frontal system, show concentrations of ozone decreasing steadily from the top of the boundary layer to the tropopause resulting in a layer ~0.5km deep exhibiting near-zero ozone concentrations at 12km. This result closely resembles profiles taken in the equatorial pacific (Kley et al.1996). Recently reported lidar measurements over Germany (Reichardt et al.1996) have also observed pronounced minima in the upper troposphere, however, such features have not previously been reported in ozonesonde data at mid-latitudes. Various mechanisms have been proposed to explain the existence of very low ozone concentrations in the troposphere, for example: heterogeneous chlorine activation on the surface of the cirrus (Borrmann et al. 1996), or by destruction in the tropics (Sander and Crutzen. 1996) and subsequent transport to higher latitudes. The processes resulting in this ozone poor layer will be illustrated using satellite images and trajectory analysis.

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TOTAL OZONE MEASUREMENTS FROM BELSK, POLAND; COMPARISON OF THE DOBSON DATA WITH THOSE FROM VERSION 7 TOMS IN 1978-1993

M. Degórska, B. Rajewska-Więch and J. W. Krzyscin (Institute of Geophysics Polish Academy of Sciences, Ks. Janusza 64, 01-452, Warsaw, Poland)

Total ozone measurements taken by means of the Dobson instrument No.84 at Belsk, Poland, were compared with the total ozone data from version 7 TOMS in the period 1978-1993. The mean difference of 4573 daily ozone means as obtained from both data sources is -0.06%, the standard deviation being 3.54%. The greatest values of the differences between the TOMS and Dobson 84 data are observed in November, December and January when the Dobson ozone measurements at Belsk are less accurate because of the lowest Sun elevations. The monthly means of daily differences between the TOMS and Dobson 84 data show no statistically significant drift of the data with time. A comparison between the ozone trend estimates for Belsk using the TOMS and Dobson data in the period January 1979 through December 1992 indicate that independently of the season the trends are in very good agreement with those previously published.

A CHLORINE MONOXIDE CLIMATOLOGY FOR THE ARCTIC FROM 1991 TO 1996 WITH UARS MICROWAVE LIMB SOUNDER DATA, ECMWF PV AND TEMPERATURE ANALYSES AND NOAA/NESDIS TOTAL OZONE COLUMN ANALYSES

Luitje Jan Dijkhuis, Finnish Meteorological Institute/EUMETSAT. Petteri Taalas, Finnish Meteorological institute.

At the Finnish Meteorological Institute is research carried out into ozone anomalies in the Arctic vortex. Ozone anomalies are a result of dynamical, chemical and radiative processes. The mutual significance of these processes is strongly variable during the life cyclus of the Arctic vortex. The years 1991-1996 are discussed. Regression statistics and individual cases will be shown for the simultanuous development of lower stratospheric ClO (NASA/UARS Microwave Limb Sounder retrievals), temperature, potential vorticity (ECMWF analyses) and O3 column (NOAA/TOVS infra-red retrievals). Elevated ClO volume mixing ratio's of 3.5ppbv at 46hPa are observed in filamentary areas with PV=40 at 475K. The areas with elevated ClO coincide with decreased total ozone columns downto 210DU. However, the elevated ClO mixing ratio's do not systematically coincide with temperatures below thresholds for Polar Stratospheric Cloud (PSC) formation.

THE GEOMAGNETIC FIELD AS A GLOBAL EXTERNAL SYNCHRONIZER OF BIORHYTHMS

A.P.Dubrov
(Int.Inf.Acad, Novatorov str. 34-4-188, 117421 Moscow, Russia)

The Geomagnetic Field (GF) is a main geophysical synchronizer of biorhythms.There is a direct relation with the high level correlation (r=0,9) between the diurnal vector variations of the GF (Inclination, I and Declination, D) and diurnal variations of a cell membrane permeability to an ions, gases,un-and organic molecules and also physiological processes in plant, animal and human organisms. A magnetic storms change suddenly and strong the cell permeability and cause heart attack, cerebral and hypertonic crises, deaths.

To prove the validity of our results it ought to compare a daily variations of the I (in thousand parts of degree !) and the D (in minutes) with a circadien rhythms of any physiological parameters (in 24-hour scale!) at the same exact time (GMT) and datum when the studies were done. A hourly values of the I and D components of GF must be taken from nearest geophysical observatory to a location of a study. Results are published in the book: A.P.Dubrov "Geomagnetic field and life. Geomagnetobiology.", NY Plenum Press Corp. 1978, 360pp.

VARIATIONS OF TOTAL OZONE IN 1970-1995: TWO-DIMENSIONAL MODEL STUDY

L. G. Dyominov, A. M. Zadorozhny (Novosibirsk State University, Novosidirsk, 630090, Russia)
N. F. Elansky (Institute of Atmospheric Physics, Moscow, 109017, Russia)

A two-dimensional model of diabatic circulation, temperature, gaseous and aerosol constituents of the troposphere and stratosphere is used to examine global variations of the ozone layer in 1970-1995.

We show that pollutions containing nitrogen, chlorine, and bromine compounds result in a decrease in total ozone. The maximum values (~ -0.25% ÷ -0.35% per year) for such variations are observed in winter in the polar latitudes of both Northern and Southern hemispheres. In this case, a season-latitude trend in total ozone is entirely due to stratospheric processes at altitudes from ~ 12 km to ~ 24 km. In the troposphere at all latitudes we recognized a positive trend (~ 0.12% ÷ 0.18% per year), wich is due to atmospheric discharges of CO and CH_4. Changes in a solar UV flux accompanying transitions of solar activity minimum to maximum result in additional changes in total ozone from ~ -0.12% per year near the equator to ~ -0.21% per year at the poles. The sink of gaseous components at the surface of aerozol particles ice, $3H_2O{\cdot}HNO_3$, and water solution of H_2SO_4 in the troposphere and lower stratosphere significantly increases the total ozone decrease only in Antarctica.

THREE-DIMENSIONAL MODELING STUDIES OF THE GLOBAL IMPACT OF AIRCRAFT EMISSIONS ON ATMOSPHERIC OZONE: SENSITIVITY TO PSC, SULFATE, AND NO_y LOADING

Richard S. Eckman and William L. Grose (NASA Langley Research Center, Mail Stop 401B, Hampton, VA 23681 USA)

The NASA Langley three-dimensional chemistry transport model (CTM) is used to examine the impact of future subsonic and supersonic aircraft emissions on ozone. Recent assessments of the affects of stratospheric aircraft on the atmosphere have emphasized the need to quantify the uncertainties in model predictions. Multiple simulations have been conducted with the Langley CTM to characterize the response of ozone to the presence of polar stratospheric clouds (PSCs), sulfate aerosols, and tropospheric NO_y from lightning. Formal assessment models have not included the impact of PSCs. We find that when PSC chemistry is enabled in the Langley model that the response of southern hemispheric ozone to a future fleet of aircraft was substantially reduced due to significant denitrification during polar winter and spring. The inclusion of chemistry occurring on sulfate aerosols also moderates the impact of aircraft NO_x emissions on ozone. The impact of an additional tropospheric source of NO_y from lightning, principally in the tropics, on aircraft perturbations will be examined.

VALIDATION EXPERIMENTS FOR NEW EXTENDED UMKEHR METHOD OF OZONE PROFILES DETERMINATION

N.F.Elansky and **O.V.Postylyakov** (Institute of Atmospheric Physics, Pyzhevsky per.3, Moscow 109017, Russia)
V.M.Dorokhov (Central Aerological Observatory, Dolgoprudny, Moscow Region 141700, Russia)
V.V.Zuev (Institute of Atmospheric Optics, Tomsk, Russia)

A new method for ozone profile retrieval, using Umkehr-similar measurement and extending its possibilities, was proposed earlier [1]. Theoretical study of extended Umkehr algorithm shows its good accuracy characteristics. To verify field accuracy of the extended Umkehr method, authors carried out correlative measurements of ozone vertical distribution using ozone sondes (Yakutsk, 62N 129E) and UV lidar (Tomsk, 57N 87E). Extended Umkehr measurements of ozone were performed by Brewer MKII instrument and spectrophotometers of the Institute of Atmospheric Optics. Results of these validation experiments are discussed. [1] N.F.Elansky , I.V.Mitin, O.V.Postylyakov. A new approach to Umkehr observations of vertical ozone distribution at ozone network. Doklagy Akademii Nayk, 347, 539-543, 1996.

TOP ACCURACY OPPORTUNITIES OF EXTENDED BREWER UMKEHR METHOD FOR OZONE P ROFILES DETERMINATION

N.F.Elansky and **O.V.Postylyakov** (Institute of Atmospheric Physics, Pyzhevsky per.3, Moscow 109017, Russia)
I.V.Mitin (Moscow State University, Vorobjevy Gory, Moscow, Russia)

Umkehr method is used for ozone profile determination at network of Brewer instruments Because currently operated inversion algorithm was initially developed for Dobson instrument, it didn't take into account particularities of Brewer. To operate Brewer and Brewer-similar instrument with full usage of its potential, extended Umkehr method for ozone profile determination is developed. The extended Umkehr algorithm is based on the on the invariant statistical estimation method. The reduction of retrieval error in comparison with Dobson-Brewer Umkehr algorithm reaches its maximum value in the lower stratosphere. Protocol of extended Umkehr observation could be optimized to increase retrieval accuracy, what gives up to 20The retrieval and accuracy analysis results are compared for multi scattering and single scattering radiative transferee models.

VARIATIONS OF OZONE CONCENTRATION IN THE PERIODS OF FORBUSH DECREASES IN COSMIC RAYS

I.N. Fedulina (Institute of ionosphere, Kamenskoe plato, 480068 Almaty, Republic of Kazakstan)

An analysis of the ozone behavior during decreasing of galactic cosmic ray (GCR) fluxes is reported. We examined total ozone data for 1978 from 29 ozone stations located in the latitudinal range of 35° - 60° N. The data were grouped in 4 crossed latitudinal ranges and analyzed by a superimposed epoch method. The days of 7 Forbush decrease (FD) maxima observed by Moscow (55.75° N) neutron monitor were used as key days. The results show, that total ozone content is decreasing almost synchronously with GCR intensity. After reduction the positive phase of ozone occurs and reaches a maximum after 9-11 days. Variations were 2 to 3% at all latitudes. For details ozone profile data from ozonesonde stations Wallops Island (37.93°N), Tateno (36.05° N), Edmonton (53.55° N) and Churchill (58.75°N) for the years 1974-1990 were analyzed. We selected 38 sets of ozone data; each of them included 3 profiles. The first was measured in the period of the FD maximum (key day); the second and the third were obtained approximately a week before a key day (quite day) and after a week respectively. The differences of first and third profiles from quite one were considered. The 20-60% ozone depletions were detected for more than 70% of FD events at the level from 100 to 200 mb. The positive changes of ozone concentration expected a week after FD were observed between 100 and 500 mb.

OZONE DEPLETION BY SULPHATE AEROSOLS AND PSCs

V. Grewe and M. Dameris (DLR, Institut für Physik der Atmosphäre, Oberpfaffenhofen, D-82230 Weßling, Germany)

Changes in ozone concentration due to different levels of stratospheric sulphate aerosol and polar stratospheric clouds (PSCs) occurence are presented using multi–annual integrations of the coupled dynamic–chemical 3 dimensional general circulation model ECHAM3.2/CHEM. Aerosols and PSCs influence the partitioning of NOY and ClY components via temperature dependent heterogeneous reactions. The interaction between the NOY and ClY catalytic ozone destruction cycles are affected in a strongly non–linear way by aerosols and PSCs. The paper especially aims at the seasonal and spartial variations of these aerosol and PSC induced changes in the partitioning of NOY and ClY and their imapact on ozone Two situations will be discussed: An atmosphere with low values of sulphate aerosol surface, which is found several years after any significant vulcanic injection of sulphur and secondly with high values of sulphate aerosol surface, representing the situation shortly after a strong vulcanic eruption.

LONG-TERM CHANGE OF PLANETARY WAVE TRANSPORT, A LINK TO THE LONGITUDE-DEPENDENT TOTAL OZONE TREND IN MEAN LATITUDES DURING WINTERS 1979 - 1992

Günter Entzian, Dieter Peters
Institut für Atmosphärenphysik, 18225 Kühlungsborn, Germany

In winters (December, January, February) 1979 - 1992 deviations from the zonal mean of total ozone (TOMS) and of the 300 hPa geopotential reveal a significant decadal change, distributed in clear longitude dependent spatial structures. While during December/January the most distinct ozone trend structures are characterised by an increase (>10 DU/10yrs) above the Atlantic Ocean and Eastern Europe and a decrease (up to -30 DU/10yrs) above Central Europe, in February the region of decreasing ozone above Central Europe is replaced by the shifted Atlantic area of increasing ozone. The ozone change and its spatial structure is investigated by a 14 layer (500 to 1 hPa) linear quasi-geostrophic transport model. The stationary waves 1 to 4 explain 50 to 70 % of the observed total ozone change via their horizontal and vertical advections. The contribution of different wave classes to the horizontal and vertical advection of ozone and its vertical distribution are discussed. It can be shown that the main influence is in the height region between the tropopause and the ozone layer maximum.

OZONE DEPLETION BY SULPHATE AEROSOLS AND PSCs

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THE GLOBAL IMPACT OF FUTURE SUBSONIC AND SUPERSONIC AIRCRAFT EMISSIONS ON THE ATMOSPHERIC OZONE COLUMN: A THREE-DIMENSIONAL MODEL SIMULATION

William L. Grose and Richard S. Eckman (NASA Langley Research Center, Mail Stop 401B, Hampton, VA 23681 USA)

Multi-year simulations have been conducted with an atmospheric chemical transport model (CTM). The horizontal dependence of the prognostic variables in the model is represented with a truncated series of surface spherical harmonics (T16 horizontal resolution) with vertical domain extending from the surface to approximately 60 km (24 vertical levels). The model formulation includes a comprehensive treatment of gas phase chemistry and heterogeneous chemical processes on polar stratospheric clouds and sulfate aerosols. The results demonstrate that the model produces a very credible simulation of many observed features of the circulation and distribution of constituents in the stratosphere, including the seasonal formation and subsequent decay of the Antarctic ozone hole. The results from a control simulation (one including emissions from an all-subsonic aircraft fleet in 2015) will be compared with results from a second simulation that includes emissions from a mixed fleet of subsonic and supersonic aircraft and a route structure assumed for the year 2015. The aircraft source emissions are taken from a compilation developed under the NASA Atmospheric Effects of Aviation Program (AEAP). Results to be presented will focus on the seasonal and latitudinalperturbations in the column ozone resulting from the aircraft emissions. Additional comparisons will be made with calculations produced by current two-dimensional assessment models to identify any significant differences arising as a result of 3-D versus 2-D dynamics in the models.

A NEW STAR-POINTING SPECTROMETER FOR MEASUREMENTS OF STRATOSPHERIC CONSTITUENTS DURING POLAR NIGHT ON SVALBARD

Birgit Heese (UNIS, P.O.Box 156, N-9017 Longyearbyen)
Kjersti Karlsen, Geir Bråthen (NILU, P.O.Box 100, N-2007 Kjeller)

A new star-pointing spectrometer consisting of a telescope and a spectrometer coupled by an optical fiber has been set up at the Auroral Station in Adventdalen near Longyearbyen, 78.1°N, 15.4°E, on Svalbard. Measurements of ozone and other stratospheric constituents which are involved in ozone depletion chemistry are mostly measured after the sun returns to polar latitudes approximately in early march. During the polar night when conditions for ozone loss are initiated, the only continuous natural light sources are provided by stars or planets. The brightest ones can be used for UV-VIS spectroscopy if enough of their light can be collected by the use of a telescope. A highly sensitive CCD camera is used with the spectrometer for detection, since light intensities from stars are poor. The coupling between the spectrometer and the telescope is maintained by an optical fiber bundle where some fibers are used for the star and some for background light from aurora. With this instrument we are able to observe an array of stratospheric constituents, i.e. ozone, OClO, NO_2, and NO_3, which are essential for the understanding of the chemical processes that take place in the stratosphere during polar night. The instrumental set-up and the first measurements from winter 1996/97 will be shown.

OZONE DIURNAL VARIATIONS OBSERVED BY UARS AND THEIR MODEL SIMULATION

F. T. Huang (Science Systems and Applications Inc.), C. A. Reber (NASA Goddard Space Flight Center) and
J. Austin (UK Meteorological Office London Rd Bracknell Berks RG12 2SZ, UK)

Several years' ozone measurements from the Microwave Limb Sounder are analysed using a 2-D Fourier series in day of year and time of day. Data are investigated between 0.46 and 21 mbar and between 28°N and 28°S. Ozone is found to be a maximum in the afternoon at 3 mbar and a minimum in the afternoon at 1 mbar and above with a narrow transition zone of reduced diurnal variation in between. Comparisons are made with results from a photochemical box model run for 28°N at spring equinox and near the solstices. In the middle stratosphere the model results are in poor agreement with the observations because of the influence of stratospheric dynamics. In the upper stratosphere, expressed in terms of the relative deviation from the midnight value, the model shows excellent agreement with the observations and in particular correctly simulates ozone in the transition zone between 3 and 1 mbar. Model sensitivity studies are performed to determine the effects of major reaction rate changes and simplified tidal effects.

QUANTIFICATION OF VORTEX LEAKAGE

B.M. Knudsen (Danish Meteorological Institute, Lyngbyvej 100, DK-2100 Copenhagen, Denmark)

Contour advection and reverse domain-filling trajectory (RDF) techniques have successfully modelled filaments of vortex air peeled of the arctic vortex in a qualitative sense. Observed filaments have shown up in the calculations, but not necessarily at the right position or with the right size. Using high resolution RDF calculations the ability to model the amount of vortex leakage will be investigated. A large number of satellite and aircraft observations of filaments will be used for this purpose. The quantification of vortex leakage is important for assessing the causes of the observed mid-latitude ozone depletion, since the transport of air primed for ozone depletion or air already depleted in ozone has a substantial influence on mid-latitude ozone.

THE CORRELATION DECAY TIME OF WIND TURBULENCE OVER THE OPEN OCEAN

Katja Henjes (James Rennell Division for Ocean Circulation, Southampton Oceanography Centre, Southampton SO14 3ZH, England, UK)

Correlations in turbulent wind speed data from the open ocean are studied. Data was obtained for wind speeds between $0.3 m/s$ and $27 m/s$; the stability range was $z/L = -2.0 \sim +0.5$. The 3 wind speed components were measured at a $21 Hz$ sampling rate with a ship-borne sonic anemometer.

The correlations are calculated via Fourier transforms of the spectral coefficients, which are computed from FTs of the measured wind speed components. It is found that all observable correlations decay within a correlation time τ of only a few seconds. This is in good agreement with the expectation to find a universal inertial range on distances small compared to the scale of vertical inhomogeneity only. However, the decay time is also possibly limited by displacements of the anemometer due to the pitch of the ship.

Inertial range spectra can be efficiently calculated using τ long runs. Nothing is gained by using longer data sections, they simply include more random noise. Some consequences for the measurement of momentum fluxes will be discussed.

A CLIMATOLOGY OF OZONE MINI-HOLES OVER THE NORTHERN HEMISPHERE

P. James (Meteorologisches Institut, Universität München, Theresienstr. 37, D-80333 München, Germany)

A climatology of occurrences of the ozone mini-hole phenomenon over mid- and high-latitudes of the northern hemisphere is constructed, based on daily Nimbus-7 TOMS total ozone measurements for the period of November 1978 to April 1993. An ozone mini-hole is a synoptic-scale area of strongly depleted column total ozone amounts, which undergoes a cycle of growth and decay, in direct association with tropospheric weather systems. A method for defining a mini-hole is introduced and used to build up a catalogue of mini-hole events, each being recorded as a daily set of tracks and minimum ozone values. The resulting climatology is analysed in terms of geographical and seasonal variations of mini-hole frequency and intensity. Possible statistical trends over the 15-year period are also assessed. Ozone mini-holes are found to be primarily a winter half-year phenomenon, are far more frequent over the North Atlantic / European sector than the North Pacific / North American sector (a major finding of the study) and exhibit a slight local orographic enhancement, being more frequent over large mountain chains. The connection to synoptic weather systems is illustrated by correlating mini-hole occurrence with large-scale weather circulation type ("Grosswetterlagen") statistics over Europe. Ozone mini-holes occur in regions of strong upper tropospheric ridging, usually between the warm sector of a cyclone and a blocking surface anticyclone.

STATISTICAL STUDY OF COSMIC RAYS INFLUENCE ON TOTAL OZONE BY REGRESSION METHOD

A. Krivolutsky, G. Zaharov (Central Aerological Observatory, Pervomayskaya 3, 141700 Dolgoprudny, Moscow, Region, Russia)
N.Perejaslova, M. Nazarova(Institute of Applied Geophysics, Moscow, Russia)
G. Bazilevskaya (Lebedev Physical Institute of Russian Acad. of Science, Moscow, Russia)

The results of solar proton fluxes mesurements by russian satellite system "Meteor" since 1969 to 1994 for different intervals of energy were used jointly with total ozone data sets (ground based observation for several points in Russia) for regression analysis. Mean - year values of total proton numbers and total ozone were used for calculations. Also the results of charged particles intensity (due to galactic cosmic rays influence) at Murmansk,Moscow and Alma-Ata were used for analysis. Long-term variations of total ozone induced by cosmic rays has been revealed.

POSSIBLE MECHANISM OF SPRING OZONE DECREATION OVER SOUTH POLE

A. Krivolutsky(Central Aerological Observ. Pervomayskaya 3,141700 Dolgoprudny,Moscow Region, Russia)

Special study on base of 1-D photochemical model and numerical analysis for non-linear behaviour of oxygen minor atmospheric components was used to investigate the reaction of ozone over S.pole in presence of a very low pressure after winter. Such effect leads to reduced production of ozone and the results of model calculations has shown 50% ozone decreation in Stratosphere.The results has shown also that we can't simulate real rapid ozone decreasing if "chemical families" tecknique is used and we should solve non-linear system using little step of integration in accordance to real times of chemical relaxation.

COMPARISON OF PEROXY RADICALS CONCENTRATIONS AND OZONE GENERATION RATE FOR URBAN AND RURAL REGIONS OF RUSSIA

Genady I. Kuznetsov, Oksana A. Terekhova
Moscow State University, Department of Atmospheric Physics

Several long-term series of measurements of the surface concentration ozone, nitrogen oxides and other minor species were carried out in different urban and rural regions of Russia. Some meteorological parameters and radiative characteristics were also measured. On the base of these data concentrations of peroxy radicals and ozone generation rate were calculated. It was shown that calculated parameters are strongly depend on the atmosphere condition when concentrations of O_3, NO and NO_2 and radiation flux were measured.

To estimate the rate of ozone generation and concentration of peroxy radical the deviation from photochemical equilibrium of $O_3 - NO_x$ system was used. These quantities complex depend on clouds, sun zenith angle and atmospheric pollution. Comparison shows that considered process are much stronger in rural region then in urban.

THE EFFECT OF SMALL-SCALE INHOMOGENEITIES ON OZONE DEPLETION IN THE ARCTIC.

B. Legras and S. Edouard (Laboratoire de Météorologie Dynamique du CNRS, 24 rue Lhomond, 75231 Paris Cedex 05, France)

The chemical processes involved in the polar stratospheric ozone depletion are fairly well understood. But the effect of small scale stirring and mixing of the chewmical species involved can be misrepresented in 3D chemical transport models because of their coarse re solution. Because of the non-linearities in the chemical rate laws, especially those involving chlorine in the main catalytic cycle, these effects can be important — particularly in the Arctic. Here we use a very high-resolution horizontal transport model with a simplified ozone chemistry to show that ozone depletion is sensitive to small-scale inhomogeneities (Edouard et al., Nature, 5 Dec 1996). Under the conditions of winter 1994-1995, the effect is large enough to account for the observed discrepancies, of about 40%, between modelled and observed ozone depletion in the Arctic environment (Goutail et al., J. Atmos. Chem., 1997, to appear). Moreover our model agrees with maximum local depletion (of the order of 60% estimated from ozone soundings matched with trajectories (M. Rex, 1997). We hope to present new calculations for winter 1995-1996 during which the average depletion has been as important as in 1994-1995.

ON THE PROBLEM OF THE SPACE PARAMETERS INFLUENCE ON THE ATMOSPHERIC OZONE VARIATIONS

L.N.Makarova and A.V.Shirochkov (Arctic and Antarctic Res.Institute,Saint-Petersburg, 199397, Russia)

The data of the baloon measurements of the total ozone content at antarctic station Mirny during spring-summer of 1989 (25 cases) were compared with the correspondent positions of the Earth magnetosphere magnetopause obtained from the experimental and model data. High correlation (r=0,91) was found between the magnetopause position and such parameters as the height of maximum ozone density and the temperature at this height. Correlation between the maximum ozone density itself and the magnetopause position is a bit worse but it is rather reliable (correlation coefficient is 0.60). The results are explained in the framework of the modified conception of the global electric circuit where its external element is magnetopause which changes its position under influence of the solar wind dynamic pressure.

SUBSIDENCE AS TRACER FOR SHEARED–OFF VORTEX FILAMENTS: RETRIEVAL METHODS AND APPLICATIONS

Arndt Meier (IRF, Swedish Institute of Space Physics, Box 812, S-98128 Kiruna)

It is still an open question how much of the negative stratospheric ozone trend in mid–latitudes might be caused by transport of chemically processed or preconditioned air masses from inside the polar vortex. Air masses inside the vortex cool down during the winter period and the profiles of trace gases get crunched in the lower atmosphere, which is termed as subsidence. By determination of the amount of subsidence in the air masses probed, an identification of its origin is possible.

Here the technique is presented how the amount of subsidence is retrieved from ground–based FT-IR solar and lunar absorption spectra by combining line–shape and total column information in a global minimum search on a set of spectra recorded under different zenith angles and by analysis of a set of different dynamical tracers with different VMR profiles and different temperature sensitivity in their optical properties. Besides the determination of the subsidence itself, its use in the correction of the *a priori* VMR profiles assumed in the retrieval improves the accuracy of the reported total column amounts significantly for the 30 different trace species measured.

The demonstration of the method is given with data recorded on Spitzbergen (79°N, 12°E) in March 1995, while examples of air filaments sheared off the vortex are expected to be given for this winter 96/97 for the observation site of Kiruna (68°N, 20°E).

OZONE FORMATION: NEW PUZZLES FROM REGULAR ISOTOPIC OBSERVATIONS

Arndt Meier (IRF, Swedish Institute of Space Physics, Box 812, S-98128 Kiruna, Sweden)
J. Notholt (Alfred–Wegener-Institut for Polar- and Marine Research, Telegrafenberg A43, D-14473 Potsdam, Germany)
T. Blumenstock (Fz Karlsruhe, IMK, Box 3640, D-7602 Karlsruhe, Germany)
H. Nakajima (Nagoya University, 3-13 Honohara Toyokawa 442, Japan)

Experimental data from *in–situ*, laboratory, and optical remote sensing techniques from ground, balloon and space based platforms have well affirmed a strong isotopic effect in ozone in the stratosphere and troposphere as well as in laboratory studies. However, the theoretical understanding of ozone formation is still incomplete and fails to explain the observed isotopic signals.

The overwhelming amount of ozone has its sources in molecular oxygen, which is known to have a content of 2 permil of heavy ^{18}O. Compared to this figure, we observe a relative enrichment of 11 % in symmetric $^{16}O^{18}O^{16}O$ and 15 % in asymmetric $^{16}O^{16}O^{18}O$ in sunlit airmasses and a significantly lower enrichment during polar night. At the end of polar night even a full diurnal cycle is observed on a particular day, which is phase shifted for the two species studied. We will extend our present analysis of ground–based FTIR spectra from Kiruna (68°N, 20°E) and Ny-Ålesund (79°N, 12°E) and correlate it to different parameters from trajectory analysis. Possibly we might be able to derive a recombination rate for ozone.

TRENDS IN OZONE LAMINAE - GEOGRAPHIC DEPENDENCE

P. Mlch and J. Laštovička (Institute of Atmospheric Physics, Boční II, 141 31 Prague 4, Czech Republic; jla@ufa.cas.cz)

Our previous analyses showed that there was a strong trend in positive laminae in ozone profiles at higher middle latitudes (~50° N). This trend is expressed best for the overall ozone content in laminae per profile, where it attains a decrease by about 50% per 20-25 years. In this paper, we deal with trends in ozone laminae at higher (Resolute) as well as lower (Tateno) latitudes. The trends seem to be comparable at all latitudes studied. On the other hand, their "ozone" origin is different - in Europe, the trend is essentially caused by a decrease of the number of laminae, while in Canada the decreasing size of laminae prevails. At least part of these changes is attributable to changes in circulation. The above results concern laminae of size >40 nbar. We present also some results for laminae >30 or 20 nbar.

ON THE STRATOSPHERIC STRUCTURE OF THE ZONALLY ASYMMETRIC INTRASEASONAL AND INTERANNUAL OZONE VARIABILITY IN BOREAL WINTERS

Dieter Peters, Karl Martin Greisiger, Günter Entzian
Institut für Atmosphärenphysik, 18225 Kühlungsborn, Germany

An extended SVD analysis (singular value decomposition) was used in combination with a linear transport model to examine the stratospheric structure of the zonally asymmetric intraseasonal and interannual ozone variability in northern hemispheric winters. The data sets are based on detrended monthly mean values of column integrated ozone (TOMS, version 6) and three-dimensional geopotential fields (14 levels between 700 and 2 hPa; NMC-data) from 1979 - 1992. The first four modes of SVD analysis explain more than 70 % of the covariance for the intraseasonal variability and more than 80 % of that for the interannual variability. A clear wave-1 pattern for modes 1 and 2 and a wave-2 pattern for modes 3 and 4 are found in the stratosphere, which show different but generally westward tilted phases. The results of linear transport model calculations for ozone will be shown and discussed.

THE OZONE FULL CONTENT VARIATION IN PERMAFROST REGION

M. I. Pudovkin (Institute of Physics, St. Petersburg State University, St. Petersburg, Russia 198904)
G. V. Starkov (Polar Geophysical Institute, Apatity, Russia 184200)

The spatial distribution of ozone over the territory of the USSR for the period 1972-1979 is studied. It is shown that for cold seasons the permafrost boundary coincides with the area of higher ozone content and with the area of higher atmospheric transparency. For non-permafrost areas the ozone content increases towards the higher latitudes, in permafrost region the dependence of ozone content on latitude is very weak. The explanation of these phenomena is given.

TOTAL OZONE DISTRIBUTION OVER POLAND FROM VERSION 7 TOMS DATA (1978-1993)

B. Rajewska-Więch and J. W. Krzyścin (Institute of Geophysics Polish Academy of Sciences, Ks. Janusza 64, 01-452, Warsaw, Poland)

The total ozone distribution (TOD) over Poland is inferred from the new Version 7 TOMS data. The data used consist of the monthly means of total ozone (TO) in the period October 1978 through April 1993 for 80 grid cells of 1° by 1.25° (latitude by longitude) covering the area of Poland. The seasonal variations of TOD have been found, i.e., rougly speaking, the TO isolines are along the meridians in winter but perpendicular to the meridians in the early spring (March, April); in November it seems that the isolines are inclined to the meridians. It appears that there are only small differences between the long-term (1978-1993) TO monthly means over the different parts of the analyzed region. In extreme cases, it is possible that in a selected month of the period 1978-1993, especially during winter, the TO monthly means somewhere in the analyzed region could differ by more than 5% of the TO calculated from the TOMS overpasess over Belsk in this month. Several statistical characteristics are examined to find long-term evolution of the TOD over Poland. The seasonal and year-round trends from the TOMS overpasses over Belsk are almost equal to those in the TO averaged over all grid cells in the analyzed region. For all grid cells, almost similar drift of TO towards lower values can be inferred. However, this drift seems to be accompanied by slightly larger TO depletion along the west border relative to that along the east border of the considered region.

5 YEARS OF OZONESONDING AT S. PIETRO CAPOFIUME STATION (ITALY)

F. Ravegnani, G. Giovanelli, G. Trivellone, CNR - FISBAT Institute
M. Banzi, C. Carbonara, ARPA Emilia Romagna - SMR
I. Kostadinov, Bulgarian Academy of Science - STIL

A monitoring activity of stratospheric ozone monitoring started in summer 1991 at S. Pietro Capofiume Station, in the Southern Po Valley, near Bologna. Weekly ozone sonding are performed via ECC ozone sensor toghether with meteorological radiosonde, in order to measure the vertical profile of ozone concentration, temperature, relative humidity, wind speed and direction up to 35 Km. For each sounding the ozone column is calculated from the vertical concentration profile and compared with simultaneus Dobson measurement, in order to check the quality of the ozone sonding. Dobson measurements are performed in the AD wavelenght pair, 3 to 5 time a day, depending on the sesaon, with Dobson #66, which was calibrated against NOAA secondary standard #65 in May 1993. The 5 years data recorded at S. Pietro Capofiume station is presented and discussed, toghether with satellite data.

OZONE AND NITROGEN DIOXIDE MEASUREMENT BY MEANS OF AN AUTOMATIC DOAS STATION AT TERRA NOVA BAY (ANTARCTICA)

F. Ravegnani, G. Giovanelli, G. Trivellone , CNR - FISBAT Institute
A. Antonelli, P. Agostini, ENEA - Brasimone
I. Kostadinov, Bulgarian Academy of Science - STIL

A Differential Optical Absorption Spectrometer (DOAS) was developed at the FISBAT Institute for atmospheric trace gases (ozone, NO2, OClO and BrO) measurements during the last few years. After several tests both in laboratory and in Antarctic region, the spectrometer, called GASCOD, was modified in collaboration with ENEA for unattended and automatic measurement in extreme enviroment. The instruments was installed in December 1995 in the Antactic Italian Station at Terra Nova Bay. The aim of this research is the study of denitrification processes during the formation of the so-called ozone hole over antarctic region. The preliminary data for the first year of measurement are presented and discussed.

THE STRATOSPHERE OVER DUMONT D'URVILLE, ANTARCTICA, IN WINTER 1992

Ph. Ricaud and E. Monnier (Bordeaux Observatory, CNRS/INSU, BP 89, 33270, Floirac, France)
F. Goutail (Service d'Aéronomie du CNRS, Verrières-Le-Buisson, France)
C. David and S. Godin (Service d'Aéronomie du CNRS, Université de Jussieu, Paris, France)
F. Lefèvre (CNRM, Météo-France, Toulouse, France)
L. Froidevaux and J. W. Waters (JPL, Pasadena, California, USA)
J. Mergenthaler, J. B. Kumer and A. E. Roche (Lockheed Palo Alto Research Laboratory, California, USA)
H. Pumphrey and R. S. Harwood (Department of Meteorology, Edinburgh University, Edinburgh, UK)

This analysis presents the temporal evolution of stratospheric constituents above the station of Dumont d'Urville in Antarctica from mid-August to mid-September 1992. Data sets include temperature, H2O, ClO, O3, NO2, ClONO2, HNO3 and CH4 mixing ratios and aerosol extinction coefficients at 46, 21 and 10 hPa given by the Microwave Limb Sounder and the Cryogenic Limb Array Etalon Spectrometer instruments aboard the Upper Atmosphere Research Satellite. Aerosol scattering ratios together with integrated O3 and NO2 amounts are given by a Lidar and a SAOZ instrument located at the station, respectively. Columnar O3 is also provided by the Total Ozone Mapping System instrument, completed with potential vorticity from the UK Meteorological Office assimilated data set. The study clearly emphasizes the correlation between the presence of the station inside the vortex and the activation of chlorine in the lower stratosphere (46 and 21 hPa). Evolution of integrated O3 and NO2 amounts together with temperature, O3 and H2O mixing ratios in the middle stratosphere (10 hPa) are strongly correlated to the position of the vortex with respect to the station. Others effects, such as rehydratation of the middle stratosphere inside the vortex, are also observed. Evidence of the presence of polar stratospheric clouds in the lower stratosphere can be deduced from available CLAES and Lidar data during the five-day period 25-29 August 1992.

AN OZONE CLIMATOLOGY (1986-95) OF THE HIGH-ALPINE SITE AT JUNGFRAUJOCH (46°33' N / 07°59' E / 3,580 M ASL) IN SWITZERLAND

E. Schuepbach and P. Zanis (Climate and Background Ozone (CABO), Physical Geography, University of Berne, Hallerstrasse 12, 3012 Berne, Switzerland)
S.A. Penkett (School of Environmental Sciences, University of East Anglia, Norwich NR4 7TJ, United Kingdom)
Paul S. Monks (School of Chemistry, University of Leicester, Leicester LE1 7RH, United Kingdom)

Diurnal and seasonal ozone cycles based on half-hourly ozone means from 1986 to 1995 are presented. Evidence is provided that Jungfraujoch - in the winter - is clearly situated in the free troposphere. A spring ozone maximum is displayed in association with northwesterly winds. This features, which is common to remote / clean-air sites in the mid-latitudes on the northern hemisphere, has for long been explained in terms of stratospheric ozone intrusions. It is demonstrated, however, that at least part of the spring ozone maximum at Jungfraujoch may be due to tropospheric photochemistry. Ozone concentrations in the extended summer (April-September) season are higher with southeasterly winds than with northwesterly winds; this is due to transport of chemically processed air to the Jungfraujoch.

OZONE HOLES IN AN ATMOSPHERE WITH INCREASING CO2

D. Shindell and D. Rind (NASA Goddard Institute for Space Studies and Columbia University, 2880 Broadway, New York, NY, USA 10025)

A coupled chemical/radiative/dynamical GCM is used to investigate the atmospheric response to increasing emissions of carbon dioxide. The model consists of a parameterized treatment of stratospheric chemistry included on-line in the GISS GCM, which contains a full treatment of radiation and dynamics from the solution of the primitive equations. Chemistry includes chlorine activation by heterogeneous reactions on PSCs, whose formation is temperature dependent. We have simulated the ozone response to increasing CO2 in both equilibrium and transient experiments. Ozone changes feedback on both the radiation and dynamics in this interactive model. Our experiments have indicated that the mid-latitude photochemical response of stratospheric ozone to increasing CO2 is highly dependent on the tropospheric temperature response and changes in residual circulation. In the polar regions, equilibrium experiments show that CO2 induced cooling of the lower stratosphere leads to significant increases in the vertical, horizontal, and temporal extent of the Antarctic ozone hole at large chlorine levels. This cooling, combined with a reduction in the frequency of sudden warmings, also dramatically increases ozone losses in the Arctic. Our transient experiments contain projected trends in both carbon dioxide and chlorine based on IPCC growth scenarios. The development of the Antarctic ozone hole as well as a significant 'hole' that forms in the Arctic under the more realistic transient scenarios is shown. Losses peak during 2010-2020 in our model for CO2 emissions following the 'business-as-usual' scenario, and chlorine loading following the Copenhagen amendments to the Montreal Protocol.

DETECTING THE IMPACT OF AIRCRAFT INDUCED OZONE CHANGES IN 3D CLIMATE SIMULATIONS

R. Sausen, B. Feneberg and **M. Ponater** (DLR, Institut für Physik der Atmosphäre, Oberpfaffenhofen, D-82230 Weßling, Germany)

Aircraft induced NO_x emissions have been shown to provide a significant increase to the tropospheric ozone concentration. This leads to an additional radiative forcing of the climate system and suggests the possibility of a significant climate impact. Comprehensive 3D climate models have to be used, if the net climate impact (including feedbacks) is to be estimated. As the impact can be expected to be rather small (compared to, for example, CO_2 doubling studies), the detection of the 3D structure of the response and its statistical significance with respect to natural climate variability exhibits a non-trivial problem.
To account for this, we have conducted a hierarchy of GCM experiments, using model configurations with prescribed sea surface temperature as well as with an interactive mixed-layer ocean. The temperature response to the prescribed ozone increases (taken from aircraft sensitivity studies with CTMs) will be shown to be statistically significant, if a sophisticated signal detection strategy is applied. In the northern hemisphere, the structure of the signal is rather similar to that simulated in greenhouse warming studies. Hence, the effect of aircraft induced ozone on the atmosphere acts to increase the "global warming" arising from the accumulation of long-lived greenhouse gases in the atmosphere.

HOMOGENEITY ANALYSIS OF THE SURFACE OZONE RECORD (1986-1995) AT JUNGFRAUJOCH (3,580 m asl) IN SWITZERLAND

E. Schuepbach, P. Zanis, M. Baudenbacher (Physical Geography, CABO, Univ. of Berne, Hallerstrasse 12, 3012, Berne, Switzerland)

Ozone data recorded continuously at the international high-alpine research site at Jungfraujoch in the Swiss Alps have been tested for the existence of potential inhomogeneities. Three different tests were used and applied to deseasonalized monthly ozone means (absolute homogeneity test) for the periods 1986-1995 and 1988-1995 as well as to formulated times series extracted by the difference of Jungfraujoch ozone monthly means from the corresponding Zugspitze ozone monthly means for the periods 1986-1994 and 1988-1994 (relative homogeneity test). The tests revealed trend and shift discontinuities. With the trend discontinuity we do not know how much is attributed to the unremoved long term natural and climatic variability, and how much to an artificial reason. Analysis of other atmospheric variables such as wind speed, temperature, global radiation and pressure show trend discontinuities very close in time with the trend discontinuity of the ozone data. This finding provides evidence that part of the trend discontinuity is natural. The observed shift discontinuity may, however, be attributed to a change in the instrument. Further analysis is necessary to correctly adjust the Jungfraujoch ozone record.

COMPARISON OF VARIOUS COLUMN OZONE FORECAST PROCEDURES IN AUSTRIA

S. Simic, P. Weihs, (Institut für Meteorologie und Physik, Universität für Bodenkultur, Türkenschanzstraße 18, A-1180 Wien, Austria).

In this work we study the accuracy of different column ozone forecasting procedures. We use for these investigations the measurements of column ozone which have been performed at Sonnblick observatory since Summer 1993. This study is performed in two steps: in a first step we study the calculation routines used within various existing forecast methods and compare the calculations performed with those with the data of Sonnblick observatory for the period 1993 to 1996. For these first comparisons only measured - and not ECMWF forecasted data - temperature, geopotential and vorticity fields are used. In a second step we look at the accuracy of the same calculations performed with ECMWF forecasted data.
At last a forecast routine for Austria is presented.

ON THE EFFECT OF JOINT INFLUENCE OF 11-YEAR SUNSPOT CYCLE AND QBO ON INTERANNUAL WINTER-TIME VARIATIONS OF OZONE OVER NORTH-EASTERN EUROPE.

B.E.Soukharev (Department of Climatology, St.-Petersburg State University, 10 linia, 33, 199178, St.-Petersburg, Russia)

On the basis of monthly mean total ozone data for the period of 1973-1995 the analysis of possible connection between variations of ozone over North-Eastern Europe (reevaluated data on 5 Russian stations: St.-Petersburg, Moscow, Murmansk, Pechora and Arkchangelsk are used) in months from November till March and January means of 10,7-cm solar flux is conducted. For the analysis the all data were grouped according to easterly (E) and westerly (W) phases of QBO. On first step of the investigation the data for winters with influence of eruptions of El-Chichon and Mt.Pinatubo (1982/83, 83/84, 91/92, 92/93) as well as linear trends were excepted from initial ozone time-series. From these filtered time-series the monthly ozone anomalies were calculated (only anomalies which exceed standard deviation were taken into account). It was turned out, that in February and March the negative ozone anomalies during E and W phases correspond to solar maximums and minimums respectively, and vice versa for positive anomalies. There were 7 cases in February and 5 cases in March which were in agreement with this dependence. There was only one exception from it (in March). On second step of research a linear correlations between ozone and solar activity separately for winters with E and W phases of QBO were calculated. It was found that during W phase there are significant positive correlations in February and March: r=0,52 (February) and r=0,56 (March). On the contrary, during E phase there are significant negative correlations in these months: r=-0,86 (February) and r=-0,59 (March). So, in the paper the results which clearly show that interannual ozone variations over Northern Europe in February and March may be mainly caused by joint influence of QBO and sunspot cycle, will be published.

A SPECTROSCOPIC DATABASE FOR SATELLITE REMOTE SENSING OF CHLOROFLUOROCARBONS

P. Varanasi and V. Nemtchinov (Institute for Terrestrial and Planetary Atmospheres, The University at Stony Brook, NY 11794-5000, U.S.A.)

Since chlorofluorocarbons (CFCs) have been proven to be effective in destroying atmospheric ozone, there has been an intensive effort to monitor the atmospheric concentrations of these compounds using satellite remote sensing. Atmospheric spectroscopic detection of the CFCs requires accurate laboratory data on the absorption cross-sections. We present here the extensive data that we have obtained in our laboratory on the absorption cross-sections in the important thermal infrared bands of CFC-11 ($CFCl_3$), CFC-12 (CF_2Cl_2), CFC-14 (CF_4), HCFC-22 ($CHClF_2$), and CCl_4. These data obtained at temperature-pressure combinations representing various model atmospheres are useful in the interpretation of data obtained in solar-occulatation type satellite remote sensing missions.

Stratospheric Arctic winter and spring profiles of N_2O_5, NO_2, and HNO_3, measured by MIPAS-B

G. Wetzel, H. Oelhaf, F. Friedl-Vallon, G. Maucher, M. Seefeldner, O. Trieschmann, T. v. Clarmann, and H. Fischer
(Institut für Meteorologie und Klimaforschung, Forschungszentrum / Universität Karlsruhe, P.O.B. 3640, D-76021 Karlsruhe, Germany)

Vertical profiles of HNO_3, N_2O_5, and NO_2 inside the arctic vortex were retrieved from nighttime infrared limb emission spectra measured by the Michelson Interferometer for Passive Atmospheric Sounding, Balloonborne version (MIPAS-B) instrument from Kiruna (Sweden, 68°N) on February, 11 and March 21, 1995, as part of the Second European Stratospheric Arctic and Midlatitude Experiment (SESAME). Spectra were analyzed by a multiparameter nonlinear least squares fitting procedure in combination with an onion-peeling retrieval algorithm. The HNO_3, N_2O_5, and NO_2 results were derived from spectral features within the bands near 11.4 μm, 12.5 μm, and 6.2 μm, respectively From the spectra of the February flight, peak mixing ratios of 10.2 ppb HNO_3 at 28.2 hPa, 1.1 ppb N_2O_5 at 17.1 hPa, and 2.8 ppb NO_2 at 12 0 hPa pressure altitude were inferred. Results of both flights are compared to each other and interpreted in the context of ozone-relevant chemistry.

DECREASE OF TOTAL OZONE AT LOW LATITUDES IN THE SOUTHERN HEMISPHERE BY A COMBINATION OF ADIABATIC AND DIABATIC PROCESSES

H. Teitelbaum and M. Moustaoui (Laboratoire de Météorologie Dynamique, Ecole Polytechnique, 91128 Palaiseau, Cedex, France)
P.F.J. van Velthoven and H. Kelder (Royal Netherlands Meteorological Institute, P.O. Box 201, 3730 AE De Bilt, The Netherlands)

Detailed analysis of the edge of the Antarctic polar vortex shows that it must be considered as a region of finite latitudinal extent rather than as an infinitely narrow boundary. A refined definition of the external boundary of the vortex edge allows the study of events where the edge becomes strongly dilata ted towards lower, even subtropical, latitudes. Such events have been observed by Argentinian subtropical UV measurement stations and can also be found in TOMS total ozone observations. The dilatation of the vortex edge begins as an adiabatic deformation of isentropic surfaces, but eventually leads to irreversible diabatic mixing at low latitudes, where the horizontal gradients in Ertel potential vorticity are small.
The dilatation of the vortex edge in the studied events is demonstrated to be due to the action of a planetary wave with wave number one. Planetary waves do not only affect the low latitude ozone by causing vortex edge dilatation events, but may also by themselves lower the ozone column, as they will adiabatically decrease the isentropic density of the ozone layer in some regions (and increase it in other regions).

NONZONAL HEATING RATES IN THE STRATOSPHERE CAUSED BY LARGE-SCALE TOTAL OZONE INHOMOGENIETIES.

P.Vargin (Moscow State University,E-mail:vargin@sancy.phys.msu.su)

Resent studies of stratospheric dynamics have shown the possible importance of nonzonal ozone heating caused by absorption of solar radiation on large scale inhomogenities of total ozone for generation of planetary transient waves and atmospheric tides. Harmonic analysis of TOMS (Ver.7) global ozone data from 1979 to 1994 was applied in order to explore the spatial structure and temporal variation of ozone nonzonalities. The magnitudes of total ozone first harmonics reached of about 30-100DU in latitudial belt -60°-70°S.Hem-re and for September-October periods. The parameterization of ozone heating rates for Huggins, Chappius and Hartley spectral bands suggested by Strobel(1978) and regression method Bojkov (1969) which permits to restore vertical ozone distribution using total ozone values were applied for investigation spatial structure of nonzonal part of ozone heating. The results of calculation of nonzonal ozone heating for September-October period caused by existing in the Southern Hemisphere ozone large-scale nonzonality revealed the most important role of Huggins band for 40-45km levels and Chappius band for 20-25km. The corresponding magnitudes of first harmonics of nonzonal heating reached 1 deg./K for Huggins and 0.1 deg./K for Chappius band.

ST15/OA30 Changes of UV-B radiation in the atmosphere

Convener: Krüger, B.C.
Co-Convener: Röth, E.-P.

OBSERVATIONS OF CHANGES OF THE TOTAL OZONE CONTENT AND SOLAR UV-B RADIATION IN THE ATMOSPHERE OVER UKRAINE

A.V.Belyavskii (Ukrainian Hydrometeorological Institute, Kiev 252650 Ukraine)
G.M.Kruchenitskii (Central Aerological Observatory, Dolgoprudnii 141700 Russia)
V.V.Naumov (Institute of Physics, Kiev 252028 Ukraine)

The changes of the total ozone content (TOC) and solar UV-B radiation (UVBR) in the atmosphere are of great scientific interest due to its vital importance for elaboration of the justified recommendations toward the environmental protection of the biosphere and human health. The regular TOC and UVBR observations were begun in Ukraine since 1973 and continue now at 6 ozonometric and 3 actinometric stations that are equipped by Guschin's filter apparatus covering a territory at sites with latitudes from 45ON to 51ON. The rich experimental material (more 10,000 sets) and comprehensive theoretical analysis of long-term series of measurements allowed us to realize a procedure of extracting of statistically significant information, detection of seasonal and latitude variations, allocation of annual motion, influence of solar activity, estimation of linear and nonlinear trends. On this base we have found an original method to recover the UVBR field using the TOC, ground albedo and cloudiness data. We have developed also a universal computer technique of construction of the distribution of daily dozes of the UVBR flux (irradiance) for any region of Earth's surface using the meteorological satellite pictures. As Ukraine already has own regional ozonometric network, one can provide a good basis for creation a real-time monitoring system to measure and map the TOC and UVBR data that will have a potential to be connected with the European network.

EFFECTS OF CLOUDS ON GLOBAL AND DIFFUSE SPECTRAL UV IRRADIANCE

M. Blumthaler, R. Wild (Institut für Medizinische Physik, Müllerstr. 44, A-6020 Innsbruck, Austria)
A.R. Webb (University of Manchester Institute of Science and Technology, Department of Physics, Sackville St., Manchester M60 1QD, United Kingdom)

The transmission of clouds for solar radiation is nearly independent on wavelength. However, the effect of clouds on global irradiance differs for different wavelengths, because the contribution of diffuse and direct components to global irradiance depends on wavelength. Therefore global UVB irradiance is less reduced by the same situation of cloudiness than global UVA and visible irradiance. This wavelength-dependent effect was experimentally investigated by simultaneous measurements of spectra of global and diffuse irradiance for the wavelength range of 290 to 400 nm during a campaign in June 1996 in Manchester (UK) under conditions with fast varying cloudiness. Additionally, the attenuation of the direct beam by clouds was recorded continuously by a silicium detector with a teflon diffuser which was shielded from the sun every second by a rotating shadow band. The percentage attenuation of the direct beam was about the same for the broadband silicium detector and for the individual wavelengths of the spectrum. The coverage of the sun by clouds was much more significant for the effects of clouds on global irradiance than the amount of coverage of the total sky by clouds. Finally, a parameterization of the attenuation of global spectral irradiance based on the data of the relatively simple rotating shadow band only is calculated.

INVESTIGATION OF PROPAGATION OF UV-B RADIATION IN THE EARTH'S ATMOSPHERE WITH TAKING INTO ACCOUNT OF ATMOSPHERIC AEROSOLS

P.N. Douriaguine and G.M. Teptin (Physics Department, Kazan State University, 18 Kremlin St., Kazan, 420008, Russia)

As it is known, atmospheric aerosols play an important role in radiation transfer in the earth's atmosphere. Their importance significantly grows up at consideration of UV-B radiation. This work is one of the steps on the way of investigation of the problem of UV-B radiation propagation in the Earth's atmosphere with taking into account effects of multiple scattering by the atmospheric aerosols. As the initial equations in these sort of problems the general equations of multiple scattering - the Dayson's equation for the averaged amplitude of electromagnetic field and the Bethe-Salpeter' equation for the correlation function of the electromagnetic field, are used. Unfortunately, the analytical solution of these equations has not been found yet. In our case we use suggested by Molyneux approach, which allows to pass to the solving simplified differential equation but with keeping multiplicity of scattering process.
Using this equation for radiation transfer problem together with using of the model of spatial distribution of atmospheric aerosol particles we numerically investigated the laws of propagation of electromagnetic radiation in the aerosol contained media. The comparison of the obtained results with results received from the single scattering model shows, that the cases then the difference between them is significant are not so rare for UV-B radiation. So in most cases it is necessary to take into account the multiple scattering effects.

SURFACE UV FLUX IN JERUSALEM - MODEL AND MEASUREMENTS

A.Y. Dvorkin (Department of Atmospheric Sciences, Hebrew University, Jerusalem 91904, Israel)
E.H. Steinberger (Department of Atmospheric Sciences, Hebrew University, Jerusalem 91904, Israel)

Total UV flux between 290 - 385 nm wavelength was measured in Jerusalem since 1988 by an Eppley UV radiometer. The results indicated a positive trend in the total flux.
In order to evaluate the changes in both UV-A and UV-B, a one-dimmensional numerical model was constructed to compute the surface UV-flux as a function of wavelength, total columnar ozone , solar zenith angle and aerosols. (Other parameters can be introduced if necessary). In order to facilitate comparison of model results with measurements, hourly flux values were computed and total UV, UV-B and UV-A fluxes were obtained. Total columnar ozone values were available, thus model values could be tested by measured ones. The agreement was rather good. Furthermore, an attempt was made to partition the measured UV flux into UV-A and UV-B, by using model results. The variations of the UV-B part of the total UV flux were well correlated with ozone changes.

SOLAR UV-B VALUES IN TWO LOCATIONS IN SPAIN

R. García Herrera (U.Complutense de Madrid,Facultad de CC. Físicas, Cátedra de Física del Aire)
Juan Cisneros (Instituto Nacional de Meteorología)
Juan Manzano (Instituto Nacional de Meteorología)
Angel Flores (U. Complutense de Madrid)
Manuel Bañón (Instituto Nacional de Meteorología)

Daily and hourly values of solar UV-B radiation (320-295nm) for Madrid (655 mts above sea level and located in the center of the country) and Murcia (43 mts above sea level and about 50 km from the Mediterranean coast) are presented.Measurements have been performed with two Brewer Mark IV spectrometers and they cover a period of 3 years (1994-1996) in Madrid and 18 months (mid 1995- 1996) in Murcia*.The main descriptive statistics as well as the time series parameters for both places will be presented.
The relationship with daily total ozone measurements (obtained with the same devices) is also investigated for both locations
* Quality and checking procedures will be described.

ESTIMATION EUV AND ITS VARIATIONS CONNECTED WITH SOLAR ROTATION ON THE BASE OF IONOSPHERIC OBSERVATIONS

G S. Ivanov-Kholodny (IZMIRAN, 142092 Troitsk, Moscow Region, Russia)

A few methods of indirect EUV estimation were proposed on the base of ground measurements in the past. The well-known method EUV estimation with help of F10.7-index is good only for meaning estimation. When we compared EUV(F10.7) and EUV(satellite data) for period November, 1979 - August, 1980 result was not so good. the difference between relative variations was up 50%. We realized an estimation of EUV variations on the base of every day data of parameters E-layer ionosphere. It gives us possibility for controlling of changes EUV on the small interval about a few period of solar rotations. The next questions will be discussed: 1) Is it possible to know before hand - what period of estimation EUV on the base F10.7 is not correct? 2) Is it possible to use another methods of estimation EUV in these periods? 3) Our method of EUV estimation with help ionospheric data may it be more good that F10.7 method in these periods? 4) Why F10.7-index is not so good and which structure and dynamics processes on the Sun are caused for this? 5) If there is total information about the different types of variations of EUV and Far UV including solar rotation and QBO of solar activity it is possible to develop a physical hypothesis about QBO-event in the Earth atmosphere?

ANALYSES OF THE POWER RADIATION AMPLIFICATION FACTOR (RAF) BASED ON THE BREWER DATA TAKEN AT BELSK, POLAND, 1993-1996

J. Jaroslawski, J. W. Krzyścin (Institute of Geophysics, Polish Academy of Sciences, Ks. Janusza 64, 01-452, Warsaw, Poland)

Daily doses of the erythemal solar ultraviolet radiation (SUVR) reaching the ground at Belsk, Poland ($52°N, 21°E$) measured by the Brewer spectrophotometer No. 64 during 1993-1996 in conjunction with daily total ozone and integrated global solar radiation are examined to infer their associations under all sky conditions. The observed doses are normalized using daily doses obtained from a parametric model (modified Bird and Riordan model).
A multiple regression model is fitted to the erythemal SUVR fractional deviations. The model explains about 95% of the variance in the normalized SUVR doses. The regression coefficients of this model define so-called power RAF. The estimates of RAF are significantly different from 1. This supports the hypothesis that the linear RAF coefficient is not valid to calculate the SUVR response to large changes in the ozone forcing factors (relative to their reference values). In view of the model's results it seems possible that daily doses of the erythemal SUVR at ground level are less sensitive to the ozone changes during overcast days than those during cloudless days.

ALTITUDE DEPENDENCE OF UV-RADIATION

P. Koepke, A. Ruggaber, H. Schwander (Meteorologisches Institut der Universität München, Theresienstr. 37, D-80333 München, Germany)

UV radiation increases with altitude level in the atmosphere, due to decreasing amount of air molecules, ozone, aerosols and of clouds above the relevant surface. This effect is known from measurements and modelling. Besides the parameters mentioned above, in the altitude dependence of UV radiation also variations of surface albedo and elevated horizon are included. The altitude effect depends on wavelength, on receiver geometry and is different for elevated surface and the same altitude level in the free atmosphere. These effects are systematically analysed by numerical modelling. Realistic combinations of the parameters depending on altitude are taken into account. Parameterizations of the UV dependency on altitude are given, which is relevant for radiation estimates e.g. for the UV-Index.

ABOUT THE SEASONAL VARIABILITY OF UV-B SOLAR RADIATION OBSERVED ON THE WEST BLACK SEA COAST

S.I.Kolev , G.I.Kortchev (National Institute of Meteorology and Hydrology, Blvd. Tsarigradsko chaussee No. 66, 1784 - Sofia, Bulgaria)
D.Kostova (Resort Albena -Ecology Department, Varna, Bulgaria)

In case of a relatively constant ozone concentration in the atmosphere , the UV-B radiation reaching the Earth surface at the resort Albena, situated on the Bulgarian North-Wast Black sea coast, is determined mainly by the clouds and amount of atmospheric aerosols. Ultraviolet radiation in the band "B" (UV-B) from the sun affects biosphere and plays an important role in the atmospheric chemistry. The aim of the present study is to describe statistically the relationships between the temporally meteorological parameters (relatively humidity, clouds base & thickness, aerosol contents, etc.) and the corresponding measured magnitudes of the ultraviolet radiation in order to be performed a short-term prediction of the behaviour of UV-B. The method of data analysis includes standard statistical procedures and multiregressional linear models on the base of the least-square fitting equations. From the performed investigation it can be argued that the correlation coefficients are the highest when the meteorological parameters exceed some "critical" magnitudes , assuming that the ozone maintains constantly its contents in the atmosphere .

PRODUCTION RATE OF OH AT AN ISLAND AND A SUBURBAN SITE IN GREECE DURING THE 1996 PAUR CAMPAIGN

K. Kourtidis, C. Zerefos, A. Bais and D. Balis (Laboratory of Atmospheric Physics, Campus Box 149, Aristotle University of Thessaloniki, 54006 Thessaloniki, Greece)
R. Schmitt (MeteorologieConsult GmbH, Glasshuetten, Germany)
B. Rappenglueck, P. Suppan and P. Fabian (Lehrstuehl fuer Immissionsforschung, University of Munich, Germany)

During the 1996 PAUR campaign, concurrent ground measurements of O3, J(O[1D]), humidity and C4-C12 hydrocarbons have been performed at two sites in Greece during the period 1.-15.6.96. The measurements allowed for the calculation of OH production rates as well as relative destruction rates for the OH reaction with various hydrocarbons. The conditions during the experiment were typical for the etesian wind period, with high N-NE winds, good vertical mixing, high ozone values with low diurnal amplitude and high relative humidity. Due to the relatively high ozone and humidity values, production rates of OH were high during the period of the measurements. Concurrent total ozone and aerosol optical depth measurements as well as model simulations are used to derive information on the factors controlling J(O[1D]) and hence OH production in the troposphere.

EFFECTS OF THE TOTAL OZONE COLUMN ON TROPOSPHERIC CHEMISTRY.

B. C. Krüger, A. Martilli, and J. Kübler (Laboratoire de Pollution Atmospherique et Sol, Ecole Polytechnique Fédérale de Lausanne, CH-1015 Lausanne, Switzerland)

Changes of the atmospheric total ozone column by more than 10 % can happen on a day to day basis due to the atmospheric circulation as well as on a long term due to the general reduction of stratospheric ozone. Photochemical model calculations, both in three dimensions and in a box, have been performed in order to investigate the effect of a changing total ozone column on the tropospheric chemistry. A real episode of three days in September 1994 in the Athens area was chosen as an example and different assumptions for the total ozone column were made. The results show, that a reduction from 320 DU to 270 DU and the subsequent increase of the UV radiation leads to an increase of radical formation and photochemical activity in the troposphere. In the lowest layer of the model the ozone concentration increased throughout the model domain. The box model calculations showed, that only under very clean atmospheric conditions increasing radiation can lead to a reduction of tropospheric ozone.

THE SURFACE UV-EXPOSURE TREND IN THE NORTHERN HEMISPHERE MIDLATITUDES; ANALYSES OF THE 7 VERSION TOMS DATA

J W Krzyścin (Institute of Geophysics, Polish Academy of Sciences, Ks. Janusza 64, 01-452, Warsaw, Poland)

Observed trends in the UV-exposure can result from the long-term changes in the amount of stratospheric and tropospheric ozone and the cloud/aerosol properties. The new version 7 TOMS total ozone and the UV reflectivity data for the period October 1978-April 1993 over the Northern Hemisphere (NH) midlatitudes ($40°N - 55°N$) are used to examine the response of the surface UV-exposure to changes in total ozone and cloud/aerosol properties. The statistical analysis of the relation between total ozone and the UV reflectivity for selected sites (corresponding to the Dobson stations) over this region shows that the UV reflectivity and total ozone are dependent variables. It seems that they are interrelated because part of their variations would be caused by an unknown yet forcing common for these two variables. This forcing depends on season and exhibits longitudinal variations. For some regions in the NH midlatitudes (e.g. Poland) it is found that the "antropogenic" trend in total ozone is responsible for only small part of the observed long-term changes in the surface UV-exposure (about 30% in the case of the UV changes over Poland). It is possible that, in some the NH midlatitudinal regions, the long-term drift of total ozone and the UV reflectivity due to their "natural" variability are main sources of the observed long-term tendency of the surface UV-exposure.

A METHOD FOR DERIVING SURFACE UV-B FROM ERS-2/GOME AND NOAA/AVHRR DATA

R. Meerkoetter (Institut für Physik der Atmosphäre, DLR-Oberpfaffenhofen, D-82234 Wessling, Germany)

A satellite based method for deriving spatial distributions of the UV-B radiation at the surface has been developed. The effects of ozone column amount and cloud optical thickness on UV-B were taken into account by the combined usage of the new European-Space-Agency's GOME (Global-Ozone-Monitoring-Experiment) sensor onboard the European-Research-Satellite-2 (ERS-2) and the NOAA/AVHRR instrument, respectively. As examples for application, horizontal distributions of surface UV-B irradiances have been derived in different selected test sites within Europe which represent clear as well as cloudy conditions. Comparisons of satellite deduced UV-B irradiances to local surface UV-B measurements at Hohenpeissenberg (Southern Germany) have been performed. The accuracy of the method is detailly discussed in view of the uncertainties introduced by the satellite and surface measurements and by the radiative transfer model adopted to create look-up-tables which relate surface UV-B radiation to the relevant surface and atmospheric parameters.

A SATELLITE-BASED CLIMATOLOGY OF UV-B IRRADIANCE FOR ANTARCTIC COASTAL REGIONS

Manuel Nunez (Department of Geography and Environmental Studies University of Tasmania, Australia. Current address: Earth Sciences Centre, University of Göteborg, Sweden)
Kelvin Michael (Antarctic CRC and Institute of Antarctic and Southern Ocean Studies, University of Tasmania, Australia)

A technique is described to map surface UV-B irradiance (erythemal ultraviolet irradiance) for a section of the Antarctic coast bounded by latitudes 59–69 S; 140–160 E. Daily NOAA/AVHRR images have been acquired for this region over four consecutive austral spring, summer and autumn seasons (November-April) starting in 1990. A model developed by Green et al. (1980) is applied to estimate cloudless erythemal irradiance using ozone estimates from TOMS and surface albedo from NOAA/AVHRR. Cloudy irradiances are estimated as the product of the cloudless irradiance and a cloud transmittance derived from satellite imagery. For clear skies model estimates gave RMS differences (model-measurement) equal to 5.7 % of the mean measured value. For cloudy skies RMS differences gave 13.6 % of the mean for daily totals, and 4.2 % of the mean for monthly averages. Monthly statistics are presented as average monthly cloudless irradiance, average monthly cloudy irradiance, and a "worst case" monthly irradiance. Considerable interannual variability is observed in the "worst case" monthly irradiance. Depletion by clouds is very significant and is larger than interannual variability in ozone depletion. The effect of high surface albedo for snow and ice is also important.

COMBINATION OF SPECTRAL UV MEASUREMENTS AND RADIATIVE TRANSFER MODELLING

B. Mayer and G. Seckmeyer (Fraunhofer Institute for Atmospheric Environmental Research, Kreuzeckbahnstrasse 19, D-82467 Garmisch-Partenkirchen, Germany)
A. Kylling (NORUT Information Technology, N-9005 Tromsø, Norway)

In order to predict future UV changes and to investigate the influence of parameters like aerosol or clouds on ground level UV irradiance, both spectral measurements and model calculations are required. At the Fraunhofer Institute for Atmospheric Environmental Research at Garmisch-Partenkirchen, Germany (47.48°N, 11.07°E, 730 m a.s.l.) we combine spectroradiometric measurements with the radiative transfer modelling package UVSPEC using a specially developed interface (SDMODEL). On the basis of this methods, we present a systematic comparison between measurements and UVSPEC modelling results. 1200 spectra for cloudless sky, gathered during two years, have been used for this analysis. For the optimum model type – a discrete ordinate model with correction for the sphericity of the Earth – the systematic differences between model and measurement were found to be less than ±6% for wavelengths between 300 and 400 nm and solar zenith angles up to 80°. Two input parameters, total ozone column and aerosol optical depth, the latter parameterized by the Ångström formula, are needed to reach this level of agreement. The evaluated UVSPEC model together with the SDMODEL interface provides an efficient tool for the investigation of the processes that control surface UV irradiance.

A COMPARISON OF URBAN/RURAL ERYTHEMAL UV IRRADIANCES FOR GÖTEBORG, SWEDEN

Manuel Nunez and Deliang Chen (Earth Sciences Centre, University of Göteborg, Sweden)

The objectives of the study are to examine possible differences in levels of erythemal ultraviolet irradiance between the urban centre of Göteborg (57.70 N,12.00 E) and a clean island location, North Koster (58.83 N, 11.00 E). Two UV Biometers of Model 501 with an erythemal sensor were used for the comparison.
The following procedure was followed for purposes of the comparison. Firstly cloudless days were selected by examining sunshine duration data for both stations during the summer months (June, July, August). Data for Koster was processed to obtain solar zenith angles for the mid-point of each hourly or half hourly period. Similarly, solar zenith angles were calculated for the mid-point of the 10 minute period at Göteborg. Using these values, and daily total column ozone obtained at Norrköping , a clear sky model was used to normalise the data to mean ozone conditions for the region (348 DU). Data was then grouped into one degree intervals between zenith angles 35 and 55 degrees and averaged for each interval. Ratios (Göteborg/Koster) for every one degree interval were examined and mean statistics were obtained. Mean and median ratios of 0.96 and 0.89 were obtained when comparing 1996 Göteborg data with 1994 and 1995 Koster data. Data for Koster collected in 1996 is currently being examined and some preliminary results will be presented.

THE INFLUENCE OF CLOUDINESS ON BIOLOGICALLY EFFECTIVE UV-IRRADIANCE

G.Pfister and E.Putz (Institut für Meteorologie und Geophysik, Graz)

One of the most important factors influencing the transfer of UV-radiation through the atmosphere is cloudiness. The variability in time and space of this parameter complicates the measurement as well as the modelling, so that the interaction between clouds and solar radiation is poorly understood.
Erythemal weighted UV-irradiance data from a UV-Biometer model 501 from Solar Light Company, Inc. and total solar irradiance data from a Pyranometer were collected. The latter are also used as indicator for cloudiness together with half hourly reports of cloud cover and height. Surface observations of air temperature, pressure, ozone and visibility are also included in this study.
The Comparison of measured and calculated clear sky data (modelled with DISORT and TUV) will be presented, taking different types of clouds into account. The influence of clouds on UV-B on one hand and on total solar irradiance on the other hand will also be shown.

INFLUENCE OF TOTAL OZONE VARIATION ON UV-B (ERYTHEMA) RADIATION. AN ANALYSIS OF UV-BIOMETER MEASUREMENTS AT DAVOS, SWITZERLAND.

A. Renaud and J. Staehelin (Institute for Atmospheric Science, ETH-Zurich, Hoenggerberg HPP, CH-8093 Zurich, Switzerland)

Direct, diffuse and global erythemal UV-B radiation are continuously measured by the Swiss meteorological institute at Davos (1610 m a.s.l) and Payerne (490 m a.s.l.) using UV-Biometers. The measurements of the direct erythemal UV (UV-Biometer instruments) at cloudless sky at Davos were compared with a standard parameterization of the attenuation of the extraterrestrial UV radiation in the atmosphere. Daily average Ångström turbidity coefficients were determined for a whole year data set. They show an annual variation with larger values in summer than in winter so as a large day-to-day variation.The increase of direct UV-B (erythema) for a decrease of 1% of the total ozone amount is also estimated for the responsivity of the UV-Biometer and for the action spectrum of human erythema as defined by the International Lighting Commission (CIE). The values are between 1 and 1.2% (dependent on the zenith angle and on the total ozone amount) for the UV-Biometer and slightly smaller values were found for the CIE action spectrum. The comparison of the diffuse UV-Biometer measurements at Davos with the results of a radiative transfer program is now carried out.

THE INFLUENCE OF CHANGES OF UV-B RADIATION ON TROPOSPHERIC CHEMISTRY

N. Riemer, **B. Vogel**, M. Hammer, H. Vogel and F. Fiedler (Institut für Meteorologie und Klimaforschung, Forschungszentrum Karlsruhe / Universität Karlsruhe, Postfach 3640, D-76021 Karlsruhe)

Solar radiation plays an important role in tropospheric chemistry. It has an impact on the concentration of tropsopheric trace gases because it influences photolysis rates and thereby the production of radicals. The effect of declining stratospheric ozone on tropospheric trace gases can be examined by model studies.
Model results of the influence of changes of solar radiation are presented. The simulations are realized with a boxmodel, a one-dimensional and a complete three-dimensional version of the comprehensive mesoscale model system KAMM/DRAIS with the implemented RADM2 chemistry. The radiation transfer and the photolysis frequencies are calculated by the photolysis code STAR. The simulations show that the impact of changes in radiation depends on the degree of pollution of the air mass.

SURFACE ULTRA-VIOLET (UV-B) RADIATION AT HIGH ALTITUDES: A MODEL SURVEY

A. A. Sabziparvar (Department of Meteorology, Reading University, Reading, RG6 6AU, U.K)
K. P. Shine (Department of Meteorology, Reading University, Reading, RG6 6AU, U.K)

Abstract: Exposure to solar ultra-violet (UV-B) radiation is expected to increase with altitude. Over the recent years, there has been a great concern about the increased UV-B and its biological effects at high altitudes (e.g., *Blumthaler et al*, 1993). Large increases in UV reported from high altitudes in Europe and South America support this fact. Measurements of the spectral UV irradiances require precise spectroradiometers with high resolution and stability which are normally expensive. In the UV-B, the altitude effect is mainly determined by the differences in: air pressure, ozone, surface albedo, aerosol concentration, and atmospheric temperature. Using the Discrete Ordinate Method (DOM), a sophisticated radiative transfer model with high spectral resolution, the sensitivity of direct, diffuse, and total (direct+diffuse) UV irradiances to changes in altitude (up to 4 km) and solar zenith angle is investigated. The altitude effect is also examined in the presence of different type of tropospheric aerosols (urban/industrial, continental, soot, soot-sulphate, and maritime). A linear altitude-UV correlation was found for the integrated UV-B (280-320 nm) and UV-A (320-400 nm) and for the erythema, cataract and keratitis biological weighting fractions. This can be applied to interpolate the biological UV-B irradiances at different heights.

THE ROLE OF TROPOSPHERIC OZONE IN FILTERING ULTRA-VIOLET (UV-B) RADIATION

A. A. Sabziparvar (Department of Meteorology, Reading University, Reading, RG6 6AU, U.K)
K. P. Shine (Department of Meteorology, Reading University, Reading, RG6 6AU, U.K)

Abstract: Increases in tropospheric ozone due to human activities may compensate, to some extent, the increased UV-B (280-320 nm) resulting from stratospheric ozone depletion. Using a sophisticated radiative transfer method, the disproportionate role of tropospheric ozone against UV-B, suggested by *Bruhl and Crutzen* (1989), is investigated for various atmospheric conditions. The model results show that at low solar zenith angles, each 1 Dobson Unit (DU) increase in tropospheric ozone can offset the increased in erythemally-weighted UV caused by 2 DU depletion in stratosphere if a typical cloud is present. Clouds tend to elevate the effectiveness of the tropospheric ozone substantially by increasing the pathlength of the photons in the troposphere. Further, the effectiveness of tropospheric ozone in the presence of various aerosols will be discussed. The second area of research is concerned with the effect of vertical distribution of ozone on UV-B. It is demonstrated that for a fixed solar zenith angle, the effectiveness of the tropospheric ozone for filtering the biological UV radiation is mainly dependent on the height of the perturbed ozone layer relative to the scatterers. The role of changes in surface albedo in this issue is also discussed. Increasing albedo tends to enhance surface irradiances; the model results also suggest that the higher surface albedos make the tropospheric ozone more effective at UV-B wavelengths. Finally, a new index is introduced which indicates the change in tropospheric constituents which is required to offset the increased UV-B, following an ozone depletion in the stratosphere.

FREETEX '96 - PEROXY RADICAL MEASUREMENTS AT THE HIGH - ALPINE RESEARCH SITE AT JUNGFRAUJOCH (3,580 m asl) IN THE SWISS ALPS

E. Schuepbach, P. Zanis, (Physical Geography, CABO, Univ. of Berne, Hallerstrasse 12, 3012, Berne, Switzerland)
P.S. Monks (School of Chemistry, Univ. of Leicester, Leicester LE1 7RH, U.K.)
S.A. Penkett (School of Environmental Sciences, Univ. of East Anglia, Norwich NR4 7TJ, U.K.)

Peroxy radicals are of major importance for the ozone chemistry in the troposphere. Such measurements can be used to determine the relative contribution of UV radiation, NO_x and VOC for the in-situ production of ozone. Peroxy radical concentrations ($HO_2 + RO_2$), and the photolysis rate constants $J(O^1D)$ and $J(NO_2)$, have been measured continuously during April and May 1996 at Jungfraujoch. The method used was a chemical amplification technique and two associated radiometers. It was found that the relation between peroxy radical concentrations and the $J(O^1D)$ photolysis rate can provide an indication on whether or not the atmosphere is clean or semi-polluted. A good correlation between peroxy radicals and the square root of $J(O^1D)$ indicates clean free tropospheric air, whereas a good correlation between peroxy radicals and $J(O^1D)$ indicates semi-polluted air. These relations have been extracted theoretically by steady state approximations. Some example days of the FREETEX '96 campaign with interesting features are presented and discussed in relation to the photochemical theory on the formation of tropospheric ozone.

AEROSOL EFFECTS ON UV-RADIATION: CONSEQUENCES ON BIOLOGICAL PROCESSES AND PHOTOC HEMISTRY

H. Schwander, J. Reuder, P. Koepke, A. Ruggaber (Meteorologisches Institut der Universitaet Muenchen, Theresienstr. 37, D-80333 Muenchen, Germany)

The variability in UV-radiation due to varying aerosol is estimated by using an accurate matrix-operator radiative transfer model, and biological (eg. DNA-damage, skin cancer) and photochemical (photolysis frequencies of ozone and nitrogen dioxide) effects are evaluated. The variability of atmospheric aerosols is usually described by the variability of aerosol optical depth. However, other properties of the aerosol, besides the optical depth, as spectral course of aerosol optical properties, phase function, single scattering albedo, and aerosol height distribution influence the UV-radiation. All these variabilities within an adequate natural range are modeled with respect to the UV-radiation. The discussion of the results is focussed on the biological and chemical effects of the aerosol variability compared to ozone variations, as well as the resulting problems for modeling UV-radiation due to uncertainties in the aerosol description for an actual case, with and without known aerosol optical depth. A comparison between model results and measurements under different aerosol conditions is presented.

POSSIBILITY OF SPECTRALLY SELECTIVE UV-B DOSIMETRY BY AN *IN VITRO* MODEL OF PREVITAMIN D PHOTOSYNTHESIS

Irina P Terenetskaya (Institute of Physics, National Academy of Sciences of Ukraine, Kiev 252022 Ukraine)

Amount of solar UV-B radiation (280-315 nm) reaching the earth surface is dependent on many natural factors. Furthermore, ozone layer depletion implies increased intensity of the short wavelength UV-B radiation whereas air pollution hinders its penetration in the biosphere. In view of the fact that bioactivity of solar UV radiation rises steeply as the wavelength decreases, special care must be used to detect precisely both integral UV-B radiation and its spectral distribution.
Vitamin D synthesis in mammal skin is biologically important beneficial effect of solar UV-B radiation. Since the action spectrum peaks at 280 nm dropping to zero at 315 nm, photosynthesis of previtamin D is highly sensitive to the spectral composition of the short wavelength sunlight.
Additionally, profound wavelength effect on the photoisomer formation was revealed using tunable laser initiation [1]. Mathematical modeling and computer simulations of the photoreaction kinetics have provided support that "Vitamin D" dosimeter has an advantage over the majority of biodosimeters making possible not only integral UV-B radiation measurement but also its spectral distribution within 280-315 nm [2].

VALIDATION OF A FILTER INSTRUMENT FOR UV MONITORING.

B. Walravens, D. Gillotay, D.Bols=E9e, J.-F. M=FCller and P. C. Simon Institut d'A=E9ronomie Spatiale de Belgique (Avenue Circulaire, 3 , B-1180 Brussels, Belgium)

The potentialities of a four channel UV filter radiometer (GUV 511C, Biospherical Instruments Inc.) for the monitoring of UV radiation have been investigated by comparing it (a) with radiometric measurements in Uccle and during two comparison campaigns (Greece '96, Hungary '96) and (b) with modeling simulations. The four channels are respectively centred on 305, 320, 340 and 380 nm. In Uccle the GUV is compared with spectroradiometers, a OL754 (Optronics) and modified HD10 (Jobin Yvon) and with YES pyranometers. During campaigns the GUV was compared to a MKIII double Brewer, a DM150 Bentham spectroradiometer and a UV-B pyranometer. The spectroradiometers are helpful to assess individual characteristics of each GUV channel whereas the broadband instruments ensure, even in bad atmospheric conditions, a comparison between high time sampling rate data. A satisfactory agreement with both the spectroradiometer and the pyranometer was found. Moreover it is obvious by comparing with simulations that the information available from the GUV are more potent than the one provided by the less sophisticate pyranometers and because of their sampling rate around the minute, complementary to spectroradiometer measurements. As an example it is possible to evaluate the atmospheric ozone variability both during the day and or long term scale from the GUV data. Preliminary comparison with ozone determinations provided by the met. office in Uccle (IRM) from Brewer and Dobson instruments will be also presented.

ACCURACY OF THE DETERMINATION OF SURFACE CLEAR SKY UV IRRADIANCE AT AN ALPINE SITE USING ONLY COLUMN OZONE DATA .

P. Weihs, S Simic (Institut für Meteorologie und Physik, Universität für Bodenkultur, Türkenschanzstraße 18, A-1180 Wien, Austria).

Routine measurements of spectral UV irradiance and column ozone have been performed at Sonnblick Observatory (3106 m altitude) since Summer 1995 and summer 1993 respectively. These set of data are used to analyze the relationship between surface UV irradiance and column ozone.
Firstly we select the days with clear sky for the following investigations. For all the selected data we use disort model by Stammes et al.to calculate the surface UV irradiance at 305 and 315 nm using as model input an average aerosol optical depth and an average surface albedo for all the data points. We look at the average relative deviations between calculations and data. After these first comparisons we investigate whether by taking other constant values of aerosol optical depth and of surface albedo we may achieve a better agreement between measurements and calculations.
We secondly analyze the daily fluctuations of the surface UV levels and their agreement with column ozone changes. Finally an estimation of the accuracy of the determination of surface UV using only column ozone is assessed, and the contribution of surface albedo and aerosols on UV fluctuations is estimated

Field Experiment Determination Of Aerosol Radiative Properties And Effects In The Ultraviolet-B Region

B.N. Wenny and V.K. Saxena (NCSU, Dept. MEAS, Raleigh, North Carolina)
J.S. Schafer (Hughes STX Corp., NASA/GSFC, Greenbelt, Maryland)
J.J. DeLuisi (SRRB, NOAA, Boulder, Colorado)
W.F. Barnard (AREAL, US EPA, Research Triangle Park, North Carolina)

A field experiment was conducted in western North Carolina to investigate the relationship between aerosol optical properties and atmospheric transmission. Two research sites in close horizontal proximity but at different altitudes enabled measurements of the transmission of UV radiation through a 1 km slab of atmosphere. An identical set of radiation sensing instruments, including a broadband UV-B radiometer, a direct sun pyrheliometer, and a shadowband radiometer, were placed at both sites. Aerosol size distributions were also measured at the lower site. Broadband optical depth and aerosol optical depths at 415 nm, 500 nm, and 673 nm were measured for the 1 km slab. These measurements along with broadband UV-B transmissions exhibited variations based on air mass source region. UV-B transmission was negatively correlated with both broadband optical depth and aerosol optical depth. Empirical relations were developed to allow prediction of solar noon UV-B transmission if either broadband optical depth or aerosol optical depth at two visible wavelengths (415 nm and 500 nm) is known. A new method was developed for determining aerosol optical properties from the radiation and aerosol size distribution measurements. The aerosol single scatter albedo ranged from 0.75 - 0.93 and the asymmetry factor ranged from 0.63 - 0.76 at 312 nm.

ST16/OA24 Solar cycles and global climate variability

Convener: Cini-Castagnoli, G.
Co-Convener: Duplessy, J.-C.

A POSSIBLE MECHANISM FOR COUPLING THE 11-YEAR SOLAR CYCLE TO MIDDLE ATMOSPHERIC VARIABILITY.

N. F. Arnold and T.R. Robinson (Department of Physics and Astronomy, University of Leicester, UK.)

Observations of climate variability have long suggested a link with solar activity. Whilst perturbations in the direct heating of the middle atmosphere by ultraviolet radiation do not appear to be sufficient to account for the observations, transport processes may provide a suitable mechanism. In this paper a possible mechanism involving the action of planetary scale waves is investigated.

An extended version of the UK Met. Office Stratosphere Mesosphere model (ESM) was used to demonstrate that over seasonal time scales, significant changes can be made to the winter middle atmosphere temperature and wind fields due to the difference in planetary wave propagation between solar minimum and solar maximum conditions. Relatively long dynamical time scales within the winter polar vortex allow small, non-linear effects to amplify.

ROLE OF SOLAR EUV AND SOFT X-RAY RADIATION PATROL FOR GLOBAL CLIMATE VARIABILITY INVESTIGATIONS

S.V. Avakyan (Aerospace Physical Optics Laboratory of S.I.Vavilov State Optical Institute". 199034, St. Petersburg, Birgevaya 12)

The variations of solar activity influence on the weather and climate as well as on many other terrestrial phenomena and processes. The principal geoeffective part of the solar spectrum can be exactly EUV and soft X-ray fluxes, because the variations of all types: cyclic, with solar rotation, and the most intensive - during large solar flares, in these spectral ranges have the highest amplitudes. Therefore the permanent monitoring of solar EUV spectral radiation (of wavelengths less than 120 nm) for sufficiently long periods to fully assess the long-term variations is very important for global change research programme. At present in the world such a patrol does not exist but there is a plan of its realization by development of the Project "Creation of the permanent Space Patrol of Solar extreme ultraviolet and X-ray radiations". This Project was supported by the grant of Intern Science and Technology Center in 1996. The initial stage of this Project was financed by European Union with the scientific collaborators from France and Germany. In this paper the possible transfer mechanism of the upper atmosphere response on the solar activity to the ground is discussed. This mechanism is associated with the sporadic ionospheric radioemission of Rydberg states. The connection of the future Solar Patrol data with this problem is considered.

IS THERE A SUN INFLUENCE ON THE EARTH SURFACE TEMPERATURE VARIATIONS AT THE SECULAR TIME SCALE ?

C. Bertrand and J-P. van Ypersele (UCL, Institut d'Astronomie et de Géophysique G. Lemaître, Université Catholique de Louvain, 2 chemin du Cyclotron, 1348 Louvain-la-Neuve, Belgium)

Numerical experiments have been carried out with a two-dimensional zonnally aver aged global climate model in order to assess the potential impact of solar variability on the Earth's surface temperature over the last three centuries. This was done by investigating the model response to the variations in solar radiation caused by the changes in the earth's orbital elements, as well as by the changes intrinsic to the Sun.

Our results indicate that while the influence of the orbital forcing on the annu al and global mean surface temperature is negligible at the century time scale, the model shows an asymmetric hemispheric response to this forcing. The modeled global warming due to three inferred total solar irradiance reconstructions (Willson and Hudson, 1988; Hoyt and Schatten, 1993; and Lean et al., 1995) is insufficient to reproduce the observed 20th century warming. Nevertheless, the comparison between the simulated and the observed temperature variations suggest that prior to around 1970, the solar constant changes could have been a key climate forcing by introducing a large quasi-cyclic temperature variation of around 90 years associ ated with the Gleissberg cycle.

SOLAR CYCLES AND DOMINANT WINDS FROM TREE RINGS IN ARCTIC REGIONS

S. Cecchini (Ist. TeSRE/CNR, via P.Gobetti 101, 40129 Bologna, Italy)
M. Galli (Dip. Fisica dell'Università, via Irnerio 46, 40126 Bologna, Italy)
T. Nanni (Ist. FISBAT/CNR, via P.Gobetti 101, 40129 Bologna, Italy)
L. Ruggiero (Dip. Scienza dei Materiali dell'Università, Lecce, Italy)

The eccentricity of conifera trunk pith of the arctic McKenzie Delta, not reached by forest fires, can be taken as an indicator of dominant wind direction and the tree ring width in the same direction as a measure of their intensity. We have initiated such an analysis to find annual variability and first results will be presented; a possible relationship with solar cycles will be discussed.

RECONSTRUCTION OF THE GEOMAGNETIC FIELD INTENSITY USING COSMOGENIC ISOTOPES

J. Beer and St. Baumgartner, J. Masarik, H.-A. Synal, G. Wagner (Swiss Federal Institute for Environment, CH-8600 Dübendorf Switzerland)

Cosmogenic isotopes such as ^{10}Be, ^{36}Cl and ^{14}C are produced by the interaction of cosmic ray particles with the atmosphere. The galactic cosmic ray flux is modulated by the solar activity and the intensity of the geomagnetic dipole field. The solar activity is known to vary on different time scales ranging from hours to centuries and possibly also millennia. Changes of the geomagnetic dipole field seem to occur rather on time scales of centuries and millennia. Using paleomagnetic intensity records from sediment cores and a new relationship between production rate and field intensity the expected variations of the production rates of ^{10}Be, ^{36}Cl and ^{14}C have been calculated. They are compared to measured ^{10}Be and ^{36}Cl profiles in ice cores and the $\delta^{14}C$ records in tree rings and corals.

THE 11-YEAR AND THE CENTURY SCALE SOLAR VARIABILITY RECORDED IN COSMOGENIC RADIOISOTOPES IN METEORITES: INFERENCES ON THE SOLAR-TERRESTRIAL RELATIONSHIPS

G.Bonino, G.Cini Castagnoli, P. Della Monica and C.Taricco (Dipartimento di Fisica Generale dell'Università, Via P.Giuria 1, 10125 Torino, Italy and Istituto di Cosmogeofisica del CNR, Corso Fiume 4, 10133 Torino, Italy)
N.Bhandari (Physical Research Laboratory, Ahmedabad, India)

Production of cosmogenic radioisotopes depends on the galactic cosmic ray (GCR) flux, which is controlled by solar activity. The radioisotopes with suitable mean life can, therefore, serve as a proxy record of the behaviour of the heliosphere in the past, over different time scales. We have analyzed the available data of the activity ratio ^{22}Na ($T_{1/2}$=2.6 yr) to the long-lived cosmogenic ^{26}Al of about 30 chondrites which fell during the past three solar cycles. The results show a clear trend anticorrelated with the 11-yr solar cycle and increases by ~20% from solar maxima to solar minima as expected by model calculations. We have measured the ^{44}Ti ($T_{1/2}$=66.6 yr) in 11 chondrites which fell in the time interval 1840-1996. The phase of the trend of ^{44}Ti, corrected for Fe+Ni target element abundances, agrees with the calculated one, but the magnitude of the increase is 4 times higher than expected from modulation deduced solely by sunspot number. This different behaviour of the heliosphere during prolonged solar quiet periods such as at the turn of this and of the past century is discussed in connection to climatic variations.

CENTURY SCALE PERIODICITIES OF THE THERMOLUMINESCENCE TIME SERIES IN SEA SEDIMENTS: RELATION TO SOLAR VARIABILITY AND CLIMATE

G.Cini Castagnoli, G.Bonino, C.Taricco and P.Della Monica (Dipartimento di Fisica Generale dell'Università, Via P.Giuria 1, 10125 Torino, Italy and Istituto di Cosmogeofisica del CNR, Corso Fiume 4, 10133 Torino, Italy)

The profile of thermoluminescence (TL), spanning the last 2500 years, has been measured in the Ionian sea shallow water core GT89/3, with a resolution of 3.096 years, corresponding to a sampling interval of 2mm.

This sediment was previously dated by us with high accuracy by radiometric and tephroanalysis methods and shows a constant sedimentation rate (within 1%), uniform for a large area of this continental platform. The analysis of the TL time series shows clear periodicities at both decennial (see next abstract of this session) and centennial time scales. In particular, we have detected the periodicities of ~100 years, corresponding to the amplitude modulation of the sunspot number series, and of ~200 years, which is also present in the radiocarbon record in tree rings.

We discuss these results in connection with the solar-terrestrial relationships and the climatic variations in the last millennia.

THE 11-YEAR SOLAR CYCLE RECORDED IN THE THERMOLUMINESCENCE PROFILE OF SEA SEDIMENTS

G.Cini Castagnoli, G.Bonino, C.Taricco and P.Della Monica (Dipartimento di Fisica Generale dell'Università, Via P.Giuria 1, 10125 Torino, Italy and Istituto di Cosmogeofisica del CNR, Corso Fiume 4, 10133 Torino, Italy)

We have measured the thermoluminescence (TL) profile of the GT89/3 shallow water core of the Ionian sea (Gallipoli Terrace of the Gulf of Taranto). This core was previously dated by us with high accuracy. The TL profile, spanning the last 2500 years, has been obtained with a time resolution of 3.096 years, corresponding to a sampling interval of 2 mm. The analysis of the TL time series, performed with different methods, shows the existence of periodicities at both decennial and centennial (see peceeding abstract of this session) time scales. We discuss the affinity of these waves to the known cycles of the solar variability. This new profile:
a) confirms our previous analysis of the TL time series obtained by us in a different core GT14, taken in the same area, spanning the last 1800 years and sampled with a different time resolution of 3.87 years;
b) extends the previous record by 700 years;
c) confirms that the solar variability is imprinted in the TL profile of the sea sediments.

SOLAR SHAPING OF MEDIEVAL OPTIMUM AND LITTLE ICE AGE.

Y.Gallardo(ORSTOM,Institut Français de Recherche pour Développement en Coopération,32 Aven. Henri Varagnat,93143,Bondy cedex F)

It is pointed out that published periodicities found on the one hand in the time-series of central England temperature,on the other hand in the t-series of the bulk thermoluminescence profiles of recent Ionian sea cores,are certainly harmonics of a same 'fundamental' Solar forcing.In fact a multi-secular wave is well shaped from medieval optimum and little ice age,by the fitting of a low-order polynomial with decadal mud-thickness data of lake Saki.

LONG-TERM VARIABILITY OF THE MESOPAUSE WIND FIELD AS SEEN FROM TOTAL REFLECTION WIND MEASUREMENTS AT COLLM, GERMANY

Jacobi, Ch., Schminder, R. (Institute for Meteorology, University of Leipzig, D-04103 Leipzig, Germany)
Kürschner, D. (Institute for Geophysics and Geology, University of Leipzig, D-04103 Leipzig, Germany)

The upper mesosphere and lower thermosphere wind field over Central Europe (52° N, 15°E) has been recorded automatically since 1973 by daily D1 LF wind measurements at the Collm Observatory of the University of Leipzig. These measurements are useful for investigating the mean mesopause wind climatology as well as the interannual variability of upper atmosphere wind parameters. Besides oscillations with periods of about 2-3 and 6 years and some solar cycle dependencies partly significant trends especially of the zonal prevailing wind and the semidiurnal tide have been found. However, a separate analysis of the first half (containing roughly the late 70s and early 80s) and the second half (the late 80s and the early 90s) of the time series show, that the obtained long-term trend is changing and, for some of the wind field parameters, even changes its sign. This gives some hint that an oscillation with a period of about two decades is present in the upper mesosphere that is overlaid to the overall trend.

O-AGCM simulations of the influence of variations of the solar constant on the global climate.

U. Cubasch, DKRZ, Bundesstr 55, D-20146 Hamburg, Germany
R. Voss, DKRZ, Bundesstr 55, D-20146 Hamburg, Germany
G. Hegerl, MPI, Bundesstr 55, D-20146 Hamburg, Germany

Two simulations have been carried out with a global coupled ocean-atmosphere circulation model to study the potential impact of solar variability on climate using the Hoyt and Schatten estimate for the years 1700 to 1992. Results indicate that the near-surface temperature response is dominated by the long periodic solar fluctuations with global mean temperatures varying by about 0.5 K. The solar variability boosts the long periods which have so far been underestimated by a number of long simulations. The modelled temperature rise in response to the increase of the solar constant during the last century is not sufficient to explain the observed temperature rise. The solar variability induces a pattern of surface temperature change similar to the one caused by the increase of greenhouse gases, i. e. an increase of the land-sea contrast. Only during north - summer over sea regions significant differences between the response patterns of the solar variability and the greenhouse gas simulations can be found.

EFFECT OF SOLAR INFLUENCE ON CLIMATE THROUGH QUASI BIENNIAL OSCILLATIONS OF SOLAR UV

G.S.Ivanov-Kholodny, A.E.Levitin (IZMIRAN, 142092 Troitsk, Moscow Region, Russia)

Even if solar irradiance doesn't vary significantly, variations in solar UV QBO (quasi biennial oscillations of UV) have influenced ozone concentration and stratospheric temperature. We find out that El Nino Southern Oscillation (ENSO) have periodicity that connected with periodicity of QBO. It's mean that the nature of ENSO may be connect with QBO. After about 11-12 years, atmospheric QBO connected with solar UVQBO will be found in identical phase with season-year periodicity and it express the effect of solar influence on climate. The mechanism of quasi biennial oscillations of ozone and of stratospheric dynamic in connection with UV QBO is discussed

SIGNIFICANCE OF SHORT-TERM INSTABILITY OF SOLAR IRRADIANCE IN THE SPECTRAL RANGE OF 330-520 nm

Kondratyev K.Ya., Research Centre for Ecological Safety, Russian Academy of Sciences, St.Petersburg
Nikolsky G.A., Shultz E.O., Institute of Physics, State University of St.Petersburg

Conditions and causes of short-term bursts (t<90 min) of solar radiation in the spectral range of 330-520 nm, discovered in the course of high-mountain observations of the spectral transparency of the atmosphere, are discussed. The bursts, defined as "gleams", occur in spectral regions centred mainly near the lines of the Balmer series. The half-width of a "gleam" band is no more than 20 nm, its amplitude exceeds by 20-40% the level of radiation typical for the quiet Sun in the same spectral range. It is found that the source of the gleams is an active region located near the central meridian of the Sun. It is suggested that the gleam irradiance has a nonequilibrium nature. It is doubtless clear that consideration of such "gleams" may be important from the viewpoint of climate change.

GLOBAL ATMOSPHERIC CIRCULATION RESPONSE TO SEASONAL AND 11-YEAR SOLAR CYCLES

Konyaev K.V.[1], Zolotokrylin N.A.[2]
[1] N.N Andreyev Acoustics Institute, Shvernik Str 4, Moscow, 117036, Russia
[2] Laboratory of Climatology, Institute of Geography, Russian Academy of Sciences, Staromonetny Per.,29, Moscow, 109017, Russia

An attempt to relate the global atmospheric circulation of the Northern Hemisphere to the seasonal and 11-year cycles of solar irradience flux is presented. For that purpose a method is presented that aims to reduce the circulation to the time series of a single parameter. This parameter series depends on both the circulation and the external forcing time series. The correlation coefficient between the parameter series and the external forcing series depends on the forcing-circulation association. These procedures are executed for the external forcing series with different time shifts. The data of atmospheric circulation for 1899-1993 are presented by the calendar of the circulation patterns from the Dzerdzeevskii's classification. The external forcing is presented by the daytime duration series as a seasonal signal and the sunspot series as a 11-year cycle signal. On the basis of analysis it was found that the circulation is perturbed by the 11-year solar cycle with a confidence level of 0.95. Circulation response to the sunspot series is delayed for 7.5 or 18.5 years. The uncertainty in the time lag associates with periodicity of the sunspot series. Circulation response to the seasonal forcing is delayed for 17 days. As a result the phase-frequency characteristic of the Sun-circulation system is estimated in low-frequency, 11-year and 1-year bands by phase shifts and characteristic slopes equal to response lags.

SIMULATION OF COSMOGENIC NUCLIDE PRODUCTION IN THE EARTH'S ATMOSPHERE

J. Masarik and J. Beer (Swiss Federal Institute for Environment, CH-8600 Dübendorf Switzerland)

Calculations for the production of cosmogenic nuclides in the Earth's atmosphere are reported and discussed. We used a purely physical model that has been well tested with extraterrestrial materials for the calculation of cosmogenic-nuclide production rates in the Earth's atmosphere. The neutron spectra as a function of depth in the atmosphere were calculated by Monte Carlo simulations using LCS for interactions of cosmic ray particles with the Earth's atmosphere and the subsequent production and transport of secondary particles. Using calculated neutron and proton fluxes, the production rates of nuclides were calculated by integrating over energy the product of these fluxes and cross sections. We calculated production rates of ^{3}H, ^{7}Be, ^{10}Be, ^{14}C, and ^{36}Cl in the atmosphere by both galactic cosmic rays and solar protons. Calculations were carried out for various solar activities. Dependence of production rates on geomagnetic field was studied in detail, not only for the present field, but also for field intensities scaled by factors ranging from 0.05 to 2. Calculated production rates are compared with previous theoretical estimates and existing experimental data.

LONG-TERM VARIABILITY OF THE SOLAR WIND DYNAMIC PRESSURE AND ITS CLIMATE CONSEQUENCES

A.V.Shirochkov and L.N.Makarova (Arctic and Antarctic Res.Institute,Saint-Petersburg, 199397,Russia)

We studied long- term variability of the solar wind dynamic pressure for the satellite epoch - (1960-1993).There was a notable increase of this parameter since about 1972 and it still continues now while the solar spot number varies in its usual cyclic way. Comparing the rocket sounding data of the polar middle atmosphere temperature with the synchronous solar wind dynamic pressure values we found that the former parameter depends on the latter one,especially in winter and under the Eastern QBO orientation. We also found that the experimentally measured parameters of the ozone layer in the polar stratosphere depend on a position of the Earth magnetosphere magnetopause which is shifted toward the Earth with the solar wind dynamic pressure increase. We conclude that the solar wind dynamic pressure can influence the climate of the high-latitude regions during winter and under Eastern QBO orientation.

FORECASTING THE GLOBAL CLIMATE VARIABILITY FOR THE 23 SOLAR CYCLE

T.V. Kuznetsova,.L.B. Tsirulnik, V.N. Oraevsky (IZMIRAN, 142092, Troitsk, Moscow region, Russia)

A new method of nonlinear spectral analysis was used to determine periodicities in annual mean sunspot numbers W for 1700-1993 yr. The calculated model set is discussed with a global climate variability. It is shown that non-stationary hyperlong harmonic of the model set with mean period of about T=252 yr. can explain common behaviour of the global climate. It is shown that a global climate will grow warmer for the future cycle. An unussually large value of W will occur during 23rd cycle (W will be greater than 100 during the 11-year period from 1997 to 2007)

PLAUSIBLE SOLAR ACTIVITY IMPACT ON CLIMATE EVOLUTION IN CENTRAL EUROPE

A. Prigancová, M. Hvoždara and M. Bieleková (Geophysical Institute of Slovak Academy of Sciences, 842 28 Bratislava, Slovakia)
E. Nieplová and M. Lapin (Slovak Hydrometeorological Institute, Jesénova 17, 833 15 Bratislava, Slovakia)

The near-Earth space is apparently forced by varying solar activity. A number of indicators of such forcing is broadly known, first of all response effects in the variable geomagnetic field. According to recent studies meteorological elements are likely to be among the possible indicators mentioned, too. The database available allows to address Sun-weather relations of immense complexity on a more systematic basis. To follow the plausible solar activity impact on climate evolution in Central Europe the data on air temperature and precipitation for more than 100 years on the territory of Slovakia are analyzed to assess and explain the longer term trends in time series profiles studied. Some features of climate changes are discussed from the viewpoint of solar and/or geomagnetic activity evolution.

PHYSICAL REASON OF CONNECTION BETWEEN SOLAR CYCLE DURATION AND GLOBAL SURFACE TEMPERATURE.

O.I. Shumilov, O.M. Raspopov, and E.A. Kasatkina
(SPbF IZMIRAN, P.O.Box 188, St. Petersburg, 191023, Russia)

It is shown on some experimental data and model calculation that galactic cosmic rays (GCR) and episodically solar cosmic rays (SCR) can create additional aerosoles in the atmosphere. These aerosol clouds partly prevent from solar radiation input to the surface that leads in turn to some decrease of the ground temperatures. Taking into account the pronounced cyclic variations of GCR intensity it is demonstrated that the linear dependence between mean surface temperatures (Δ T) and solar activity (sunspot number W) takes place Δ T = 0,0051 W - 0,76. On the base of physical mechanism suggested it is possible to interpret the well-known dependence of surface temperatures on solar cycle duration when during longer cycles the lower temperatures were observed and during shorter cycles the higher one. In the case the cycle durations turn not to be the causal factor influencing on global temperatures because experimental study on short and long time scales demonstrate that is a rule, the shorter cycles are as well the more intensive ones. So during the more intence periods of solar activity the aerosol layer is not developed enough on account of decreased activity of GCR. Some numerical estimates of global temperatures during last 300 years seem to support the physical model developed, on particular estimates of temperature conditions of Little Ice Age formation during Maunder minimum of solar activity corresponding to enhanced aerosol formation.

RESPONSE OF A SIMPLE COUPLED CLIMATE MODEL TO EARTH ORBITAL VARIATIONS: THE ROLE OF INTERNAL NONLINEARITIES AND STOCHASTIC RESONANCE

Axel Timmermann (Max-Planck Institut für Meteorologie, Bundesstr.55, 20146 Hamburg, FRG)
Gerrit Lohmann (Max-Planck Institut für Meteorologie, Bundesstr.55, 20146 Hamburg, FRG)

A simple coupled model consisting of a northern hemisphere box ocean model and an energy balance model is used to study Late-Pleistocene climate variations. The astronomical theory of earth orbital variations is not able to explain the dominance of the 100-kyr peak in the climate record spectrum. We subject the question which role internal nonlinear climate feedbacks and stochastic pertubations (weather fluctuations) play to amplify the weak eccentricity forcing signal. The sensitivity of the model's thermohaline circulation on combined deterministic Milankovitch and stochastic weather forcing is studied. It occurs that the extreme stages of the past climate record are associated with multiple stable equlibria of the temperature-salinity driven ocean circulation.

LONGTERM VARIATIONS OF RADIATION BALANCE ELEMENTS IN THE EARTH'S ATMOSPHERE, AND COSMIC-RAY INTENSITY.

G.A.Zherebtsov, V.A.Kovalenko, P.G.Kovadlo and S.I.Molodykh (Institute of Solar-Terrestrial Physics, 664033 Irkutsk, P.O.Box 4026, Russia)

An analysis is made of the radiation balance elements and atmospheric temperature at stations of the Baikal region in East Siberia. One of the geographical features of this region is that it lies in the central part of the continent where (according to various models) major changes in climatic characteristics as a consequence of global warming are expected to occur. A clear 11-year periodicity was detected in the scattered-radiation distribution for the period 1939-1986. Scattered-radiation maxima that are most pronounced in the spring-summer period, correspond to solar activity minima and galactic cosmic-ray intensity maxima. Some models treat cosmic rays as an "agent" that controls atmospheric transparency. The amplitude of scattered-radiation variations has been decreasing monotonically since the sixties. A decrease of maximum values of intensity is accompanied by an increase of maximum values, which is likely to be attributed to anthropogenic effects. It has been found that the increase in global surface air temperature during the past decade is manifested in the region being analyzed in the form of a rise in temperature in the winter months, while in the average the warming of the northern hemisphere is due to a rise in summertime temperatures. The question of an interrelation between the variations of radiation balance elements, the circulation and air temperature of the region is discussed.

SOLAR VARIABILITY AND COOLING OF THE UPPER ATMOSPHERE AS SEEN BY LONG-TERM MEASUREMENTS OF COSMIC RADIO NOISE.

Th. Ulich, E. Turunen and H. Ranta (Geophysical Observatory, FIN-99600 Sodankylä, Finland)

Model estimates of the effects of increasing greenhouse gas emissions predict cooling of the upper atmosphere. Experimental evidence for the cooling is, however, scarce and mostly based on short time scales. Since the absorption of cosmic radio noise depends on electron-neutral collision frequency, which in turn is a function of temperature, the cosmic radio noise measurements reflect long-term changes of temperature. We analyse the long-term recordings of the Finnish riometer chain for signs of cooling of the upper atmosphere and of solar variability. The Finnish riometer chain comprises 8 riometers, some of which started operation already in 1964; the chain covers the large latitudinal range between 60°31′ N and 69°45′ N.

ST17 Pioneers in solar-terrestrial physics during the 19th and 20th centuries

Conveners: Schröder, W.; Verö, J.

INTERNATIONAL RELATIONS IN THE GGRI'S RESEARCH WORK ON GEOMAGNETISM AND RELATED STUDIES IN THE LAST 40 YEARS

A.Ádám and P. Bencze (Geodetic and Geophysical Research Institute, H-9401 Sopron, P.O.Box 5, Hungary)

In the Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences (GGRI) the geophysical research work was concentrated on three areas: geomagnetism, aeronomy and study of the Earth's interior by electromagnetic induction. For the support of these investigations an observatory was built in 1956–58 in the neighbourhood of Sopron The main field of research work in geomagnetism is the study of the propagation and transformation of geomagnetic pulsation In the field of aeronomy atmospheric electricity, Schumann resonances, the ionospheric absorption of radio waves, turbulence in the lower thermosphere are studied. Investigations of the Earth's crust and the upper mantle by the electromagnetic induction aimed first of all at the study of the Pannonian Basin, but extended also to the territory of neighbouring countries. Considering the international relations, they were the most intensive with the organizations KAPG, INTERCOSMOS. In the era of KAPG (Commission of the Academies of Socialist Countrees on Planetary Geophysics), this organisation was actually the regional branch of IUGG in the East-European countries INTERKOSMOS was also an organization like COSPAR uniting the space research activities carried out in East-European countries. At the same time the Institute maintained close connections with IUGG, EGS and COSPAR, too

MAGNETOSPHERIC PHYSICS TO 1965

W.I. Axford (Max Planck-Institut für Aeronomie, D-37189 Katlenburg-Lindau, Germany)

The development of ideas concerning the magnetosphere of the Earth up to 1965 will be reviewed. Particular attention will be paid to the concepts of the ring current, the magnetopause, the plasmasphere and plasmapause, the bow shock, magnetospheric convection, the magnetotail and substorms.

THOMAS JEFFERSON, HERBERT RIEHL AND COLD EUROPEAN WINTERS CONNECTED WITH SOLAR-TERRESTRIAL EFFECTS

V.Bucha (Geophysical Institute AS CR, Bočni II, 14131 Praha 4, Czech Republic)

Jefferson has made in his autobiography a powerful analysis of how the very cold 1788-1789 winter affected the affairs of men. Such severe cold in Paris before the French revolution began in 1789 was without example in the memory of man, or in the written records of history. According to Riehl the pattern of air flow that also brought cold winter to Europe e.g. in 1963 was connected with the air being persistently channelled westward from Russia and Siberia. The normal centres of action were reversed at the surface. A high-pressure center lay above the region of the Icelandic low; it blocked the normal westerly flow and prolonged transport of air from Russia westward. A low pressure center lay over the area normally occupied by the subtropical high-pressure belt. This is typical for cold European winters and this flow pattern, according to Riehl, probably prevailed during the winter of 1788-1789. Herbert Riehl describes similar extremes also over the United States and assumes that the roots of such abnormal air motions lie in the reactions of the atmosphere to the sun's radiation, among many factors. Thus, it was Jefferson and Riehl who demonstrated the peculiarities of extreme cold winters in Europe and in the United States. Trying to answer these questions we showed that warm winters in Europe (e.g. 1973-74, 1974-75 or 1988-89 and 1989-90) occurred when solar and geomagnetic activity was high: then, the northern jet-stream was enhanced due to downward winds from the thermosphere, the zonal flow prevailed in midlatitudes and above-normal temperatures occurred in Europe and in the southeastern part of the United States. On the other hand, during other winter periods (e.g. in winter 1976-77, 1979-80, 1986-87 and 1995-96 when geomagnetic activity was low, the northern jet stream was weak and planetary waves with large amplitudes prevailed (due to orography) which brought on severe winters to Europe and to the eastern part of North America.

SOLAR RESEARCH AND 19th CENTURY POPULARIZERS IN FRANCE. SOME EXAMPLES

Simone Dumont et Suzanne Débarbat
Observatoire de Paris

Sunspots were seen, independantly in 1611, by Fabricius, Galileo and Scheiner, through refractors recently designed. During two centuries, they will represent the only aspect of what is now called the solar activity. Without success, studies are made upon their influence on the climate.
A new evolution will come during the 19th century, with the solar spectrum (Fraunhofer, 1814), the periodicity, around ten years of the number of sunspots (Schwabe, 1843) and the solar cycles from 1749 (R. Wolf ,....). The last one organizes the regular observations of the sunspots. Other aspects of solar activity are discovered : proeminences during the total eclipse of 1842 July 8, flare with polar auroral manifestation magnetic storm (1859),...
Popularizers will therefore introduce the subject in their books. During the first part of the 19th century Arago will give it an important place in his *Astronomie populaire*. Figuier, Guillemin, Flammarion will do something similar, during the second part of the 19th century.
Examination of this books, from one by a high level astronomer (Arago) to one by a man dreaming about the sky (Flammarion) leads to questions on their representation on the knowledge of the time. It is a possible also, through these books easy to read, what is still valid in the works of these pioneers of astronomical popularization in France, in the field of the knowledge about the Sun.

THE HISTORY OF THE SCIENCE OF SOLAR-TERRESTRIAL RELATIONS - A reminder

Giovanni P. Gregori (Istituto di Fisica dell'Atmosfera [IFA-CNR], Sturzo 31, 00144 Roma, Italy - phone: +39-6-59293017; fax: +39-6-5915790; e-mail: gregori@atmos.ifa.rm.cnr.it)

The Sun is the prime mover of almost every phenomenon occurring in our environment, implying both the geosphere and the biosphere: hence, the science of solar-terrestrial relations includes *per se* all natural sciences. The history of the progress in every discipline is therefore pertinent to every specific topical chapter in the history of science. The present short review deals, rather, with the history of human thought from the viewpoint of Man's general philosophy, or feeling, or attitude, or subconscious conviction or believes, or "opinion science", in front of natural phenomena, and of either the presumption or the assessment of their control by the Sun. That is, this is a different chapter, or a premise, or an introduction to a table of content, dealing with an item that is better suited for a real entire encyclopedia, rather than for a review talk. Moreover, owing to the cultural limits of the author, the preeminence is given to the geosphere. This entire item, however, in addition to having an obvious historical interest, is also up-to-date, as it is concerned with some presently actively debated aspects of natural sciences, that are felt as major challenges by mass media and society.

THE BEGINNING OF SOLAR-TERRESTRIAL RESEARCH IN EUROPE

G. Haerendel (Max-Planck-Institut für extraterrestrische Physik, Giessenbachstraße, 85740 Garching, Germany)

The roots of solar-terrestrial physics were on the one hand in solar physics, and on the other hand, in atmospheric/ionospheric physics which were greatly intensified during the IGY. Among the pioneers in Europe the names of Kees de Jager, Sir Harrie Massey, Robert Boyd, Ludwig Biermann, Reimar Lüst, Tom Kaiser, Jacques Blamont, Wolfgang Priester, and Bengt Hultqvist come to mind. Several of them were also key actors in building up European space research, through the establishment of COPERS (1961) and ESRO (1964) and through national space programs. One of the foremost questions in the early sixties was still whether the expanding corona generated a solar wind or a breeze, which was soon to be decided by direct measurements. The author will report about his personal involvement in the first steps of European space research and his encounter with some of the above-mentioned heroes of this field.

RAYMOND DAVIS, JR.'S SOLAR NEUTRINO EXPERIMENT HAS REVEALED A NEW HORIZON IN SOLAR-TERRESTRIAL PHYSICS

H.J. Haubold (UN Outer Space Office, Vienna International Centre, Vienna, Austria)

The Sun is a surface source of photons and other particles and a volume source of neutrinos. Solar-terrestrial physics in common sense is governed by information gathered through the analysis of data based on gravitational, electromagnetic, and strong interactions. R. Davis, Jr. 's pioneering chlorine radiochemical experiment to detect the weakly interacting electron-type solar neutrinos, pursued since 1954, opened the view into the gravitationally stabilized solar fusion reactor. After more than 25 years of taking data in this experiment, the measured event rate is 2.55 SNU, which is a factor of 3.6 less than is predicted by the most detailed Standard Solar Model theoretical calculations, 9.3 SNU. This discrepancy is used to be called "solar neutrino problem". The challenge is still on "terrestrial" solar, nuclear, and neutrino physics to resolve this mystery.
Reference:
J.N. Bahcall and R. Davis, Jr. in J.N. Bahcall: Neutrino Astrophysics, Cambridge University Press, New York 1989, pp. 487- 530.

THE PIONEER OF MAGNETIC STORM RESEARCH: SYDNEY CHAPMAN

Ioannis A. Daglis, Institute of Ionospheric and Space Research, National Observatory of Athens, Penteli, Greece

Sydney Chapman's pioneering work on the physics of geomagnetic storms are presented and discussed. Chapman's rigorous method of analysing the rather limited observations of relevance to storm dynamics, yielded remarkably accurate results with regard to average characteristics of storms. Special mention is made to work of Chapman relevant to the much debated topic of storm-substorm relationships.

PIONEERS OF POLAR AURORAE IN HUNGARY 1768 - 1910 AND SPECTRAL SEARCH ESP. AT OBSERVATORY ÓGYALLA BY KONKOLY

L. Krivsky, Astronomical Institute, Ondrejov 251 65, Czech Republic

Miksa Hell who headed the expedition to Norway (1769) observed many aurorae together with János Sajnovics and he interpreted this events in his lectures in Copenhagen. In the interval of years 1768-78 the member of the Order Jesu J. Nep. Fierer in Tyrnau created many unique aquarelles of aurorae. Very important elaboration of aurorae was published in German and Latin Pál Makó von Kerekgede (1775, 1781). Makó explicated also the physical relation of the aurorae to the Sun in folowed working: „Das Nordlicht ist ein elektrischer Funken, der bei der Berührung der irdischen und der solaren Atmosphäre zustandekommt." Guido Schenzl (1870) studied variations of geomagnetic field in relation to aurorae and Miklós Konkoly-Thege observed aurorae with an spectroscope (1870, 1871, 1872) at the new Observatory Ógyalla (Hurbanovo, Slovakia). Further Lorand Eötvös (1871) investigated spectrum of aurorae and defended theirs electric origin. The scientific orientation of Konkoly was directed not only to the clasical astronomy, but also to the geophysics and to the meteorology. The aurora events represent processes of solar, heliospheric and terrestrial origin. Existence of this connection was described by Pál Makó already in year 1775.

A.V. D'YAKOV AS A PIONEER OF HELIOMETEOROLOGY

Leonid V. Golovanov, Russian Academy of Public Administration

In 1938 the weather forecaster Anatoly V. D'yakov (Temir-Tau, Altai, Russia) found out systematic occurrence of tropical air flows above the Western Siberia territory with a delay of 3-4 days after the culmination of the Sun active areas. Due to the air temperature increase of up to 10-15 degrees it was accompanied by heavy snow and rain falls, storm winds and blizzards in winter, thunderstorms and storm rains in summer. Simultaneously the compensatory air flows above the European part of Russia cause Arctic invasions. By this means A.V. D'yakov managed to reveal different ways of the solar activity influence on a development of atmospheric processes. Study and use of this law in a practical weather prediction during several decades allowed him to receive more reliable results than the ones of the State Department of Hydrometeorology. It has been done not only for the Western Siberia, but for other regions as well and even provided to forecast the birth and development of tropical typhoons.

A.L.TCHIZHEVSKY AS A FOUNDER OF SOLAR-TERRESTRIAL BIOPHYSICS (HELIOBIOLOGY).

Leonid V. Golovanov, Russian Academy of Public Administration
Dmitry L. Golovanov, Moscow State University

In February 1997 the scientific world celebrates the 100th anniversary of Alexander L.Tchyzhevsky (1897-1964). He was an outstanding Russian scientist, one of the pioneers of modern solar-terrestrial sciences, President of the 1st International Congress on Space Biology (New York, 1939), full and honorary member of many academies and scientific societies of Europe, Asia and America. Based on the energetic theory principles, he revealed correlation between natural processes in the Earth environment and cyclic or sporadic fluctuations of phenomena on the Sun and in the Universe. Looking for the mechanism of these links A. L.Tchyzhevsky made a number of basic biophysical and geophysical discoveries: the biological role of the air ionization, sources of atmospheric electricity (1927), electrodynamics of the blood in vivo (1953), etc. According to him the space phenomena should be taken into account in the analysis of all the natural processes on the Earth.

A LINEAR RELATIONSHIP BETWEEN AURORAL FREQUENCY OF OCCURRENCE AND SOLAR-TERRESTRIAL PARAMETERS DURING 20th-22nd SOLAR CYCLES AND 53-63°N

I.Liritzis (Academy of Athens, RCAAM, 14 Anagnostopoulou str, Athens 106 73, Greece), P.Preka (University of Athens, Dept of Physics, Division of Astronomy, Athens), R.Livesey (British Astronomical Association, Auroral Section, Britain), V.Petropoulos (Academy of Athens, RCAAM, Athens, Greece), and S.Vretos (University of Athens, Division of Astronomy, Greece)

The frequency of occurrence of aurorae borealis (A) depends upon i) the solar activity processes, ii) geomagnetic latitude of observation, iii) weather conditions, and iv) observering coverage. A linear relationship betwaen the (A), solar activity parameters (number of solar flares (F), coronal holes (H), number of sunspots (Rz)), and the planetary geomagnetic index (Ap), has been obtained per solar cycle and for the total time interval 1965-1995. The (A) data were taken from reported accounts, and also from smoothed curves of (A), against, geomagnetic latitude, per each year separately. Interesting correlations were obtained between (A) and each solar-terrestrial index, as well as a generalised relationship A=f(F,H,Rz,Ap) with high accuracy. Especially the Rz, F, H effect on (A) is strongly a function of latitude, for 53-63°N.

HISTORICAL OVERVIEW OF THE POLAR LIGHT EVENTS OVER THE SOUTHERN MIDDLE EUROPE

Inga Lisac, Ph.D., Assistant Professor

Descriptions of about 20 polar light events were analyzed, published mostly since the end of 18th century up to present days and observed within latitudes from 42° to 46,5°N and longitudes 13° - 19°E (today mostly on the territory of Croatia). The list of polar light events includes date, place and source of information and visually observed parameters such as colour, shape, distribution over the sky and time duration of the phenomenon for the most cases. Basic statistical results allowed the conclusion about the most frequent occurrence of a particular parameter. The polar light events highly correlate with the solar activity.

Work of S.Hanzlik and J.Bradka

Eva Markova. Observatory Upice, 542 32 Upice, The Czech Republic

In this paper are presented works by S.Hanzlik concerning in (intersting in) anticyclones in relation to solar activity in start of this century and to other works by J.Bradka from fifty years, in which are presented similar problems.

GAUSS' BIFILAR *H*-VARIOMETER

H. Nevanlinna (Finnish Meteorological Institute, P.O.Box 503, FIN-00101 Helsinki, Finland

During the early decades of the 19th century variations of the geomagnetic field at geomagnetic observatories were observed visually only. The most widely used method to observe changes of variometer magnets was Poggendorff's mirror-and-scale system aided with a telescope. Readings were made typically 1...12 times per hour. For observations of the horizontal field Gauss' bifilar *H*-variometer was in use at geomagnetic observatories. At the Helsinki-observatory, founded in 1838, Gauss' bifilar instrument was continuously in operation for more than 60 years. During that time about 1,000,000 readings of *H* have been accumulated. Most of the data are still untreated and are available in original observational notebooks only. The quality of the *H*-data, at least in the period 1844-48 studied here, seems to be reliable. Comparisons between Helsinki *H*-results and the present day Nurmijärvi observatory data, reveal similar daily variations curve at both observatories. In long-term changes, with varying number of annual sunspots, the daily range of *H* follows the same linear relationship as *H* at Nurmijärvi. We believe that Helsinki *H*-data series is as reliable and homogeneous as the recently analysed series of declination (1844-1909), and is suitable for detailed studies in the changes of the geomagnetic horizontal field component in the mid 19th century.

GEOMAGNETIC STUDIES IN SLOVAKIA IN THE FRAME OF SOLAR-TERRESTRIAL PHYSICS

A. Prigancová, M. Hvoždara and M. Váczyová (Geophysical Institute of Slovak Academy of Sciences, 842 28 Bratislava, Slovakia)

To trace the historical development of geomagnetic studies in Slovakia in the frame of solar-terrestrial physics a short chronological outline is presented as to operation activities at the Hurbanovo geomagnetic observatory. From the viewpoint of a rapid progress in space physics the appropriate directions of scientific program of the Geophysical Institute of Slovak Academy of Sciences are considered and some main contributions are emphasized. In addition, the attention is focused on theoretical and empirical studies based on observations at a more mature level.

PIONEERS IN SOLAR-TERRESTRIAL PHYSICS

Rokityansky I.I. (POB-338/7, Kiev-146, Ukraina)

N.P.Myshkin studied in 1900-1912 effect of solar light and other sourses on the behavior of isotropic torsion pendulum and found that the effect can penetrate through any screens. Free variations of the pendulum correlate with solar activity.
A.L.Tchijevsky (1897-1964) gave statistical evidence that solar recurrence has terrestrial response in quantity of lightning's victims, in harvest, epidemic, reproduction and migration of insects, fish, birds and animals, grouth of trees, frequency of diseases, crimes, revolutions and so on - hypothesis of heliotaraxia.
G.Piccardi in 1951-1972 fulfilled thausands experiments in different places of the Earth and proved that velocity of chemical reactions correlate with solar activity.
N.A.Kozyrev (1908-1983) supposed that time possesses special physical properties: Course of time arising from its directivity and Density of time responsible for transfer organisation (negentropy) from one system to another. Sun is a great time machine that synchronize all processes in adjacent space. Time carry angular moment, but no momentum.
This scientists gave evidence that there is a new effect in solar-terrestrial problem to be studied in next century.

MAXIMILIAN HELL: AN AURORAL STUDY IN THE 18TH CENTURY

J Verő (Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences, H-9401 Sopron, Pf. 5)

Maximilian Hell, a Jesuit astronomer born in the then Upper Hungary, in the present Slovakia, observed during a trip to Vardø (Norway) sponsored by the Danish king Christian VII the transit of Venus before the Sun, but he had also seen auroras on many occasions during the trip. His companion, János Sajnovics discovered the similarity between the Hungarian and the Finnish-Lapponian languages. Having returned to København, he drafted a work on an auroral theory, considering as its origin the reflection of solar radiation from snow and ice in the polar region and for this thesis, he received the doctor degree from the Copenhagen University. Nevertheless, he experimented during the trip with magnetic observations, too, (previously he had published a treatise on the rod magnet, thus he had been familiar with magnets), but his instrument was apparently less sensitive than he thought, thus he could not find the simultaneous changes in the magnetic field, therefore he did not accept the connection with magnetic variations. He made several interesting other observations, among them e.g. in connection with the Scandinavian uplift, discovered somewhat earlier by Swedish scientists.

ST18/OA12 Open session on turbulent boundary layers

01 Basic turbulent studies

Convener: Petrosyan, A.
Co-Convener: Gerz, T

EXPERIMENTS ON A COMPARISON OF TWO REALISATIONS OF THE MELLOR-YAMADA LEVEL 2.5 CLOSURE SCHEME.

V.A.Alexeev, J.R.Bates (Niels Bohr Institute of Astronomy, Physics and Geophysics, University of Copenhagen, Juliane Maries Vej 30, DK-2100, Copenhagen O, Denmark)

The sensitivity of the Global AGCM [1] to the parameterization of turbulent processes in the boundary layer has been studied. Earlier this model was used with the Helfand and Labraga [2] turbulence package for the boundary layer. Another realisation of the Mellor-Yamada level 2.5 turbulence closure scheme [3] was installed in the AGCM. These packages have been compared using both local 1D and full 3D simulations.

[1] J.R.Bates, S.Moorthi, and R.W.Higgins, 1993: A global multilevel atmospheric model using a vector semi-lagrangian finite-difference scheme. Part I: adiabatic formulation. Mon. Wea. Rev., Vol.121, 244-263.

[2] Helfand, H.M., and J.C.Labraga, 1988: Design of a non-singular level 2.5 second order closure model for the prediction of atmospheric turbulence. J. Atmos. Sci., 45, 113-132.

[3] Janjic, Z.I., 1994: The step-mountain coordinate model: further development of the convection, viscous sublayer, and turbulence closure schemes. Mon. Wea. Rev., Vol.122, No.5, 927-945.

SPECTRAL GAPS IN THE STABLE FLOW OF A NOCTURNAL GROUND INVERSION

J. Bange, A. Muschinski and R. Roth (Institute for Meteorology and Climatology, Herrenhäuser Str. 2, 30419 Hannover, Germany)

During a field campaign with the new airborne turbulence measurement system Helipod over a flat region in North Germany a strongly stratified turbulent flow within a nocturnal ground inversion was probed. In the middle of the inversion, in 100 m height, a layer with heavy shear was found. In combination with the suppression of vertical motions and therefore small vertical fluxes this led to small flux Richardson numbers $Ri_f \approx 0.1$. The one-dimensional power spectra of the velocity components and the temperature exhibited gaps with shapes similar to spectral gaps observed in clear air turbulence (CAT). In contrast to CAT the spectral gaps of the nocturnal inversion were found at wavelengths below 10 m. The gap wavelengths were in good agreement with Weinstock's theory (1980) of spectral gaps. Weinstock's predictions could be extended experimentally for temperature and one-dimensional velocity spectra.

TURBULENCE AT A SPLASHING FREE-SURFACE: THE FLOW REGIMES.

M. Brocchini (School of Mathematics, University of Bristol. Bristol, England BS8 1TW)

Interactions of turbulence and patches of vortical flow with an air-water interface are analysed. These can be particularly relevant to predict momentum and heat fluxes across the sea free-surface. This is particularly true when subsurface turbulence is so strong to lead to the 'splashing' regime characterised by violent mixing of gas and liquid. A range of flow regimes is inspected to derive a proper scale-dependent description of the interactions. Increasing turbulent intensity leads from a smooth surface first to a rippled surface then clearly developed micro-breaking. Further increases in turbulent intensity lead to air entrainment and drop formation giving a bubbly flow; eventually highly energetic turbulence leads to a splashing regime. We shall use these words: wavy, rippled, micro-breaking, bubbly and splashing to summarise the surface states we discuss. A sixth flow regime can be introduced in which surface deformations caused by patches of vortical or turbulent flow occur in the shape of 'scars'. Hence the name of 'scarified' or scarred. A simple description of the water flow regimes can be achieved in terms of only two main parameters. The first is a typical length λ representing either the size of the turbulent eddies or coherent patches of vortical flow. The other variable used in this discussion is the local turbulent kinetic energy density k defined in terms of the turbulent fluctuations u_i as: $k = \frac{1}{2}\langle u_i u_i \rangle$ where $\langle . \rangle$ is the ensemble average operator. Curves of marginal breaking are discussed in the (k, λ) plane.

COMPARING THE PERFORMANCE OF THE k-ε AND THE MELLOR-YAMADA LEVEL 2.5 TWO-EQUATION TURBULENCE MODELS.

H. Burchard (Joint Research Centre, T.P. 690, I-21020 Ispra (VA), Italy) and O. Petersen (International Research Centre for Computational Hydrodynamics, Agern Allé 5, DK-2970 Horsholm, Denmark)

The aim of the talk is to compare two versions of the k-ε and the Mellor-Yamada level 2.5 two equation turbulence models. Both models include a prognostic equation for turbulent kinetic energy and a length scale related prognostic equation, which in the former case is the dissipation rate of turbulent kinetic energy and in the latter case the product of turbulent kinetic energy and the macro length scale. These models are applied for a 1D numerical simulation of the water column dynamics in the northern North Sea. Wind forced non-stratified and stratified laboratory experiments are used for the calibration. It is shown that the Monin-Obukhov similarity theory is well reproduced by these models as already proved for the algebraic Mellor-Yamada level 2 turbulence closure. The considered turbulence models can in principal simulate the measured thermal dynamics of the upper ocean mixed layer during FLEX'76. It can be shown that the choice of the stability functions which are used as proportionality factors for calculating the eddy viscosity and diffusivity has a stronger influence on the performance of the turbulence model than the choice of the length scale related equation.

WIND WAVE TANK MEASUREMENTS OF BOUND AND FREELY PROPAGATING GRAVITY-CAPILLARY WAVES

M. Gade and W. Alpers (Inst. für Meereskunde, Universität Hamburg)
S. A. Ermakov (Inst. of Applied Physics, Russian Academy of Sciences)
H. Hühnerfuss and P. A. Lange (Inst. für Org.Chemie, Universität Hamburg)

Measurements of the wave amplitude and slope and of the radar backscatter at X and Ka band have been carried out in a wind wave tank with mechanically generated gravity waves as well as with wind generated waves on slick-free and slick-covered water surfaces. The goal of this investigation is to obtain further insights into the mechanisms which are responsible for the water wave damping by monomolecular surface films, in particular, to explain the measured high reductions of the radar backscattering at X and Ka band. Measurements of the radar Doppler shifts show that bound gravity-capillary (X and Ka band Bragg) waves are generated at the crests of steep gravity waves with frequencies between 3 Hz and 5 Hz. Steep 2 Hz waves do not generate bound Ka band Bragg waves. In the whole wind speed range (1.5 m/s to 10 m/s), bound harmonics contribute to the X and Ka band backscatter from a slick-free water surface, whereas their fraction on the backscattered signal depends on radar band and wind speed. Finally, it is shown that a monomolecular surface film has a strong influence on the generation of bound waves. The X band backscatter is mainly caused by bound Bragg waves at wind speeds below 7 m/s, but by freely propagating Bragg waves at higher wind speeds, where the gravity waves are strongly damped by the slick. The Ka band backscatter is mostly caused by freely propagating Bragg waves.

On the existing of the absolutely linear theory for the inamics of the isotropy turbulence

G.Golfeld (P.Shirshov Inst. of Oceanology, RAS, Moscow)

The classical problem of the theoretical analysis of space-time dynamics of fully developed isotropi turbulence is considered. We prove by using the methods of the double Fourie series that covariance of the simmetrically limited random process with its 2nd degree power is equal zero in the sense of the square-root convergency. As a result, there is a linearity of the Kharman-Howart equation for the velocity fluctuations, and for its spectral analog. Obtained linearity results from the additive character of the Reynold hypothesis. Thus, to take into account non-linearity one has to consider jointly mean flow and fluctuations.

INTERIOR AND BASIN-WIDE DIAPYCNAL MIXING IN STRATIFIED WATER: A COMPARISON OF DISSIPATION AND DIFFUSIVITY

G.-H. Goudsmit and A. Wüest, Swiss Federal Institute of Environmental Science and Technology (EAWAG) and Swiss Federal Institute of Technology (ETH); CH-8600 Dübendorf, Switzerland

Turbulence measurements and basin-scale tracer balances have been employed to estimate diapycnal diffusivity in stratified water bodies. As values inferred from these two fundamentally different approaches differ by an order of magnitude in the ocean thermocline, a series of experiments was carried out in order to quantify and to understand the mechanism of diapycnal mixing in an enclosed stratified freshwater basin.

Temperature microstructure measurements in the hypolimnion showed that about 90 % of the turbulent kinetic energy was dissipated within the bottom boundary layer (5 to 10 m thick), whereas only 10 % was lost in the interior of the stratified water body. These findings were corroborated by three fluorescent dye tracer release experiments. Injection of the tracer into the centre of the hypolimnion revealed that the diapycnal diffusivity in the interior was low ($(2\pm0.4)\cdot10^{-7}$ m^2s^{-1}), but increased by an order of magnitude (to $(4\pm1)\cdot10^{-6}$ m^2s^{-1}) upon reaching the sediment boundary. Basin-wide diapycnal diffusivities determined from heat flux measurements agreed well with the results of the vertical tracer experiments after horizontal homogenization.

The consistent results of the two completely independent methods demonstrate that diapycnal fluxes - at least in medium-sized basins - are predominantly generated by mixing within the boundary layer above the sediment.

WAVELET ANALYSIS OF TURBULENCE MEASUREMENTS UNDER STABLE STRATIFICATION

D. Handorf (German Weather Service, Meteorological Observatory, D-15864 Lindenberg, FRG)

Turbulence measurements performed in the stably stratified boundary layer (SABL) in Antarctica during the FINTUREX experiment at Neumayer station in 1994 have been analysed by means of the wavelettransformation technique (WT). The SABL supports a variety of turbulent and wave structures of instationary character. Due to its local character the WT has a lot of advantages over the Fouriertransformation for the analysis of these phenomena obtained from turbulence measurements. First results of the application of the WT for the investigation of the turbulent and wave structures are being presented. Furthermore, the associated energy transfer is determined by means of the application of the WT for filtering and conditional sampling.

LAYERED STRUCTURE EVOLUTION IN THE STABLE ATMOSPHERIC BOUNDARY LAYER

V.J. Hipkin and S.D. Mobbs (The Environment Centre, University of Leeds, Leeds LS2 9JT, UK)
P.S. Anderson (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, CB3 0ET, UK)

An attempt is made to model the evolution of layered structure associated with strongly stable atmospheric conditions. During the 1986 and 1991 STable Antarctic Boundary Layer Experiment (STABLE) at Halley, Antarctica, a high resolution, monostatic sodar was operated in conjunction with surface-layer turbulence instruments. Multiple layers which persisted for periods of hours to days were observed in the sodar backscatter records. In mast-based temperature measurements, events were observed in which a well-mixed surface layer apparently underwent rapid cooling followed by sudden stratification. Analysis of STABLE kinematic sensible heat flux data suggests that under very stable conditions increasing stablility may act to suppress surface heat flux. A mechanism is suggested through which rapid cooling of the surface brings the atmosphere into the stability regime in which suppression occurs, causing divergence in the heat flux at some height and hence the development of layered structure. A simple 1-D numerical model is presented and used to examine this mechanism.

Turbulent entrainment in atmospheric boundary layer processes

J C R Hunt, Meteorological Office, Bracknell, U.K. RG12 2SZ

Modelling turbulent entrainment plays a central role in developing meteorological and environmental models; this paper presents recent research on the mechanisms for different types of situation; in particular entrainment into the sides of growing vertical plumes and clouds and its sensitivity to internal processes, density differences and external turbulence, rates of entrainment at the top of boundary layers and stratus clouds and its sensitivity to internal and external profiles of the buoyancy frequency N.

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ROSSBY VORTICES AND DEFORMATION RADIUS EFFECTS IN PLANETARY TURBULENCE

N. N. Kukharkin and S. A. Orszag (Fluid Dynamics Research Center, Princeton University, Princeton, NJ 08544, U.S.A.)

The formation of zonal flows and vortices in the generalized geostrophic (or Charney-Hasegawa-Mima) equation in the β-plane approximation

$$\partial_t(\nabla^2 h - L_R^{-2}h) + [h, \nabla^2 h] + \beta h\partial_x h + \beta\partial_x h = D + F$$

is considered. We focus on the regime when the size of structures is comparable to or larger than the deformation (Rossby) radius. In this case an additional nonlinear term $\beta h\partial_x h$, physically analogous to the scalar nonlinearity of the Korteweg-de Vries equation which describes solitons, should be taken into account [1]. The combined influence of the β-effect (both Rossby waves and KdV nonlinearity) and deformation radius on coherent structures is studied. It is shown that for parameters close to those of giant planets large-scale zonal flows created by small-scale forcing tend to preferentially form anticyclonic vortices. Their emergence can be explained by the modified Rayleigh-Kuo instability criterion which takes into account the deformation of free surface. We have provided numerical evidence that for scales larger than the Rossby radius, the scalar nonlinearity is responsible for the formation of ring anticyclonic vortices with quiescent cores consistent with observations of the Jovian and oceanic flows. Physical mechanisms that lead to these phenomena and their relevance to turbulence in planetary atmospheres are discussed.

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MEAN-FIELD HYDRODYNAMICS FOR ROTATING FLUIDS.

A.S.Petrosyan and D.Yu.Polounine (Space Research Institute, Russian Academy of Sciences, Profsoyuznaya 84/32, Moscow, 117810, Russia)

Many turbulent flows that must be understanded are subjected to a rotation The present study is concerned with Reynolds Averaged Navier-Stockes equations for rotating system with and without convection. There are two basic observations: limited application of the turbulent viscosity hypothesis and possibility for turbulent viscosity became negative in rotating systems. Our prime interest here is with the finding nontrivial parametrisations of Reynolds stresses describing contribution of turbulence to the large-scale momentum flux. Nontrival dynamics of large-scale flows exist when turbulence in rotating system has been treated. It has been found that non-helical component of the turbulent field and the presence of the rotation lead to the additional terms in the Reynolds stress tensor. These terms are proportional to the first spatial derivatives and may cause an additional wave-like transport of momentum. Helical component of basic turbulence leads to the phase velocity difference of such wave-like motions in direct and backward propagating directions. In the presence of convection, described in Boussinesque approximation, we found the possibility for decreasing turbulent viscosity value as compared rotating system without convection.

TURBULENCE STRUCTURE AND LENGTH SCALES IN THE VICINITY OF CIRRUS CLOUDS: OBSERVATIONS DURING ICE AND EUCREX

Markus Quante, Ehrhard Raschke, GKSS Research Center, Institute for Atmospheric Physics, D-21502 Geesthacht, Germany

Turbulence in the upper troposphere is directly linked to the structure and life cycle of cirrus clouds through internal mixing and entrainment processes. A better understanding of the turbulence structure and dominant scales at cirrus level is of great importance for cloud resolving numerical models and for the development of adequate parameterization schemes for larger scale models. Cirrus clouds cover large areas of the globe and are an important factor in the radiation budget of the Earth. During the International Cirrus Experiment (ICE) and the European Cloud and Radiation Experiment (EUCREX) extended aircraft measurements of turbulence in the upper troposphere were made. Here we will summarize the results and present typical turbulence parameters and length scales for different types of cirrus clouds and background flows. Integral- and buoyancy wavelengths, isotropy factors and spectral characteristics obtain by conventional and wavelet analysis will be discussed.

COOL AND FRESHWATER SKIN OF THE OCEAN DURING RAINFALL

Peter Schlüssel (Meteorologisches Institut, Universität München, Theresienstraße 37, 80333 München, Germany)

Rainfall over the sea modifies the molecular boundary layers of the upper ocean through a variety of different effects. These cover the freshwater flux stabilizing the near-surface layer, additional heat flux established due to rain versus surface temperature differences, modification of physical parameters by temperature and salinity changes, enhancement of the surface roughness, damping of short gravity waves, surface mixing by rain, and transfer of additional momentum from air to sea. They are separately described and included in a surface renewal model to investigate the rain's influence on the cool skin of the ocean and the creation of a haline molecular diffusion layer. Simulations with the upgraded model show that the most important effect on the conductive layer is that of enhanced turbulence reducing the surface renewal periods followed by additional surface cooling due to rain on the order of 0.1 K. Comparisons with field data of the cool skin taken during the Coupled Ocean Atmosphere Response Experiment confirm the model results.

Geophysical boundary layer study
V.Shnaidman, A.Tarnopolsky
Odessa Hydrometeorological institute

Determination of geophysical boundary layer (GBL) is given. A closed system of hydrodynamics equations is formulated for quantitative description of GBL non-stationary three-dimensional internal structure. Closure of the system is carried out with the turbulence kinetic energy (TKE), dissipation rate (DRE) equations, Kolmogorov and Smagorinsky relationships. The reasons of using TKE and DRE equations in the GBL problem are adduced. The choice of constants in the turbulent characteristics equations is discussed. The boundary conditions for atmospheric and oceanic boundary layers are formulated. The numerical algorithm of the solution the non-linear task is developed. The possibilities of the GBL model to applied problem are demonstrated. As an example, the GBL modelling results over Ukraine for typical hydrometeorological conditions are presented.

COMPARISON OF TURBULENT DISSIPATION RATES MEASURED IN THE BALTIC SEA AND IN ALPINE LAKES

Adolf Stips, CEC-JRC, Space Applications Institute, 21020 Ispra, Italy
Hartmut Prandke, ME-GmbH, 24610 Trappenkamp, Germany

In 1995 and 1996 several measurement campaigns were made at the Baltic Sea and at Lake Maggiore (North Italy). The microstructure measurements were performed by using the uprising version of the Enhanced Dissipation Profiler EDP, which was developed as a prototype within the EUREKA/EUROMAR project MICSOS. The effects of several wind events are clearly seen in the two dimensional depth-time plot of the measured dissipation rates. The periods with higher turbulence intensity occurred in periods of increased wind speeds. The near surface layer down to a depth of 2 m, with variable and mostly higher dissipation values compared to greater depth, is due to the effect of surface waves. Wind induced Turbulent Kinetic Energy (TKE) production and dissipative loss correlate well. The loss due to dissipation varies between 5 and 15% of the production. The dissipation responds quickly (in less then one hour) with increased values to the on-set of wind events. The observed delay between the termination of the wind driven TKE production and the final decay of turbulence was found to be about 4 hours. In general no "wall layer" profiles were found for the depth decay of dissipation. For wind speeds below 5 m/s the upper layer down to a depth of 2 m beneath the surface shows a z-3 decay, whereas the deeper layer between 7 - 2 m exhibits a linear decrease. It was not possible to confirm the subdivision of the SBL into 3 sublayers proposed by Terray et al. 1996.

EFFECT OF LAGRANGE - SCALE TURBULENCE ON THE POLLUTION INTENSITY OF UNDER-SURFACE ATMOSPHERE FROM GAS-AEROSOL SOURCE.

Volodimir M. Voloshchuk, professor, the head of meteorology and climatology chair of the Kiev T. Shevchenko University

The essential of the research involves direct accounting of Lagrange-scale turbulence L at parametrization of vertical turbulence diffusion of gas-aerosol impurities in the steady field of horizontal wind. The necessity of such clear accounting stems from the fact that at the distance of point source of gas-aerosol impurity R, satisfied the condition of R < 10 H, where H is the height of the boundary layer of the atmosphere, the known condition of feasibility of semiempirical K-theory of turbulent difusion: l>>L, where l - specific scale of non-uniformities of an average concentration of impurities, deliberately is not fulfilled. It was used the hypothesis of delta-correlating of the transferred-by-wind field of vertical turbulent air accelerations. It was shown that the hypothesis gives the distribution of aerosol impurity transferred in the free atmosphere from the point sources, which is satisfactorily matched with the results of full-scale experiments. The integro-differential equations were obtained to account the vertical turbulent flow of gas-aerosol impurities at arbitrary value of relation l/L.

TURBULENT KINETIC ENERGY DISSIPATION IN THE UPPERMOST SURFACE LAYER OF NATURAL WATERS

A. Wüest and A. Simon, Swiss Federal Institute of Environmental Science and Technology (EAWAG); CH-8600 Dübendorf, Switzerland

The vertical structure of small-scale turbulent mixing in the uppermost surface layer of natural waters is - due to experimental difficulties - whether well resolved nor well understood. As turbulent kinetic energy is often simultaneously produced by wind (due to large scale shear, the action of waves and Langmuir circulation) and by convection as a result of night-time cooling, is has been difficult to separately study the driving mechanisms. In order to evaluate the effect of the different contributions to dissipation ε we analysed experimental observations from a medium-sized lake, taken under different external conditions.

Data has been continuously collected during 12 days in March 1996 in the surface layer of Lake Neuchâtel. The set includes meteorological data, wave gauge and acoustic current measurements, CTD profiles and several hundred profiles of temperature microstructure.

Microstructure-based profiles of dissipation ε, determined for different wind velocities and surface buoyancy fluxes will be presented and compared to theories and analytical turbulence model results.

MIXED LAYER DEPTH AND EKMAN PROBLEM

Ch. Zülicke, C. Sattler (Baltic Sea Research Institute, Seestr. 15, D-18119 Warnemünde, Germany), A. Stips (Satellite Applications Institute, I-21020 Ispra (VA), Italy)

The Surface Mixed Layer is studied analytically. It is assumed that the major properties are reflected in a moving slab model of the Kraus-Turner type. The mixing depth and the drift velocity are derived from this consistent model: the Ekman drift for finite depth and the mixing depth for a drifting surface layer are combined. The most important point is the proper treatment of turbulence-producing shear through the mixing layer.

The analytical solutions are discussed. The results are evaluated in conjunction with in-situ measurements of surface fluxes, drift velocity and dissipation profiles.

ST18/OA12 Open session on turbulent boundary layers
02 Studies of atmospheric surface fluxes

Convener: Foken, T.
Co-Convener: Valentini, R.

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MEASUREMENT OF FLUXES EXCHANGED BY A FOREST ECOSYSTEM IN ARDENNE'S FOREST

Marc AUBINET (Dept. of Physics, Faculté des Sciences Agronomiques de Gembloux, Belgium)
Narasinha SHURPALI (Dept. of Biologie, Universitaire Instelling Antwerpen, Belgium)

In the frame of the EUROFLUX program (European Community), a set up which measures the fluxes exchanged a forest ecosystem has been erected in Vielsalm (Belgian Ardenne forest). The site is a mixed forest constituted by beeches (*Fagus sylvatica*) Douglas fir (*Pseudotsuga menziesii* (Mirb.)Franco) and Spruce (*Picea Abies*). Fluxes of momentum, sensible heat, water vapour, and carbon dioxide are measured continuously on a half hour basis in using the eddy covariance method. In addition, measurements of air, soil and biomass temperature, air humidity, soil water content, incoming radiation, precipitation, CO2 profiles in the air canopy are performed. We present the results of measurements performed on this site during a first 6 monthes period. In particular the mean daily courses of different fluxes are presented and discussed :

- the energy balance over the site is shown as well as the repartition of available energy between sensible and latent heat flux.
-two independant estimations (by eddy covariance and sap flow measurements) of the water vapour flux are compared
- finally, a first estimation of the net carbon flux is given, and its daily course is discussed in relation with the storage of CO2 in the air inside the canopy.

ENERGY BALANCE CLOSURE AT THE ANCHOR STATION THARANDT

M. Berger, T Grünwald and Ch. Bernhofer (Institut für Hydrologie und Meteorologie, Technische Universität Dresden, Piennerstr. 9, D-01737 Tharandt, Germany)

Since July 1996 eddy covariance measurements were carried out to estimate the energy and mass fluxes over a spruce forest (*Picea abies*) at a tower of 42 m height. The Anchor station, where the tower is situated, is one location to measure CO_2 and water vapor fluxes within the EUROFLUX project. This projects deal with measurements and process studies to investigate the possible influence of varying CO_2 fluxes and water vapor fluxes in the climate system, especially in the European forests.
Sonic anemometer and close path gas analyzer measurements are made. At Tharandt a high velocity air stream (> 50 l/min) transport the air turbulently in a 59m tube to the measurements hut where a secondary stream probes for H_2O and CO_2 concentrations with 8 l/min. This set-up allows easy access to service the gas analyzer but careful spectral analysis for time lag of wind and scalar signal is necessary. To estimate the fluxes a typical time lag of 10 to 15s was found with two independent methods. All fluxes were also corrected for frequency response. The energy balance closure for the Anchor Station Tharandt could be computed and problems of the closure will be discussed.

SEASONAL VARIATION OF WATER AND CARBON EXCHANGE AT THE ANCHORSTATION THARANDT

Ch. Bernhofer, M. Berger, C. Frühauf and T. Grünwald (Institut für Hydrologie und Meteorologie, Technische Universität Dresden, Piennerstr. 9, D-01737 Tharandt, Germany)

Water vapor and carbon dioxide fluxes of a spruce forest are monitored contin uously at the Anchorstation Tharandt as part of the EUROFLUX programme to assess the role of temperate European forests within the global carbon cycle. Based on a site adapted eddy covariance technique (EC, see Berger, M. et al.) water and carbon transport relationships can be established (see Grünwald et al.). To explore the potential to utilize these relationships for a long term assessment of the carbon exchange of the larger forested area *Tharandter Wald* several aspects of turbulent fluxes are addressed: (i) duration and importance of interception, (ii) source areas and (iii) use of the energy balance closure as indicator variable for the applicability of the EC technique.
Data of 1996 show an important role of intercepted water. A changing source area probability was detected that could be categorized in dry episodes, episodes with dominant transpiration and episodes with dominant interception listed with increasing distance to the point of measurement. Energy balance closure was good for unstable and fair for stable stratification. An interception, thermal stratification of the surface layer, and the diurnal/seasonal courses of surface fluxes of gaseous atmospheric constituents are not independent variables. Consequencies for mass balances of these constituents are discussed.

THE INFLUENCE OF VEGETATION COVER ON NIGHTTIME SURFACE TEMPERATURES AND ITS REPRESENTATION IN NUMERICAL WEATHER PREDICTION.

M.J. Best (Meteorological Office, London Road, Bracknell, RG12 2SZ, United Kingdom.)

On radiation nights, when the turbulent fluxes of heat and moisture are negligible, surface temperatures have a dominant influence on the surface layer temperatures. Inaccuracies in the surface temperature can therefore have important impacts on, for instance, fog formation.

Detailed observations of radiation, temperature, humidity, wind and precipitation, collected over a period of three months at MRU Cardington, England, are used to force a model of the surface exchange scheme employed in the UKMO Unified Model. The surface temperatures and fluxes from this model are compared with those measured at the field site over a period of several days.

The results of the comparison show that a layer of vegetation must be included in the surface temperature parametrisation to represent accurately the dominance of radiative fluxes over the ground flux in the energy balance and hence the surface temperature.

SPATIAL VARIABILITY OF TURBULENT FLUXES ABOVE A FOREST

P.B. van Breugel, and W. Klaassen (dept. Physical Geography, RUG, Kerklaan 30, 9751 NN Haren, the Netherlands)
E. J. Moors (DLO Winand Staring Centre, PB 125, 6700 AC Wageningen, the Netherlands)

Spatial variability is analysed to validate flux aggregation schemes and to derive corrections for measurements with insufficient fetch conditions. Fluxes of momentum and sensible and latent heat were measured in may and october 1995 at two locations and several heights in a heterogeneous wood in the Netherlands near Veenhuizen. The wood consists of coniferous as well as deciduous species of various height and leaf area index. The shortest distance from the tower to the same forest edge was respectively 50 and 800m. Flux measurements were obtained with a sonic anemometer and a Gill propellor anemometer, in combination with krypton hygrometers and fast response the rmocouples. Variation in the wind direction caused differences in the fetch as well as a different angle of incidence to the forest edge. Flux differences between the two locations are related to differences in species composition as well as to fetch.

LONG TERM MEASUREMENT OF FLUXES OF CARBON DIOXIDE CO_2 AND WATER VAPOUR OVER FOREST

Z Chen (Wind Energy and Atmoshperic Physics Department, Risø National Laboratory, DK-4000 Roskilde, Denmark)
N. O. Jensen and P. Hummelshøj

A long term monitoring system for fluxes of CO_2 and water vapour, using the eddy-correlation method, is set up in a 57m tall mast in a beech (*Fagus Syluatica*) forest in Denmark. It is part of the EC sponsored EUROFLUX project. It consists of a Gill sonic anemometer and LI-COR 6262 for eddy correlation plus a rang of slow response instruments for profile analysis. Ancillary measurements such as soil humidity and leaf area index are also done. The data are recorded and stored in a local computer but can be transfered from the site to our office by modem at any time. The set up of instruments is described. Roughness and zero-plane displacement are compared by the traditional wind profiles and a simple mass conservation method. Spectra of CO_2 concentration and air humidity are analyzed. The diurnal and seasonal patterns of carbon exchange and evapotranspiration are investigated.

SURFACE FLUXES OF NO_2 DETERMINED BOTH BY EDDY-CORRELATION AND VERTICAL GRADIENT METHODS ALONG THE SPANISH COAST

C. Cieslik (Environment Institute, Joint Research Center, Ispra, Italy)

In recent years, surface fluxes of NO_2 represented a matter of discussion since it was not clear whether they were directed down- or upwards. Instrumental artefacts were suspected to alter the data, as well as chemical reactions. This work consists in a series of measurements carried out in parallel with the eddy-correlation and vertical gradient methods over an orange tree orchard along the Spanish coast. The fast-response NO_2 analyser was carefully calibrated and compared with a slow sensor and proved to have a very good performance. Fluxes determined by both methods showed satisfactory agreement; they were directed upwards in low NO_2 regime (see breeze) and downwards in high NO_2 regimes (land breeze). Analysis of the data give clear indications that NO_2 advected from the neighbouring city undergoes deposition; were no advection occurs, upward NO_2 fluxes may be explained by NO emitted by the soil and rapidly converted to NO_2 by chemical reaction.

LONG-TERM MEASUREMENTS OF POLLUTANT AND ENERGY FLUXES ABOVE CORN, PASTURE, AND SOYBEANS

J.F. Clarke*, P.L. Finkelstein* and T.G. Ellestad (U.S. Environmental Protection Agency, Research Triangle Park, NC 27711) (*On Assignment from NOAA)

This paper reports on a collection of long-term surface flux measurements of O_3, SO_2, CO_2, and HNO_3 to corn, pasture, and soybeans; the measurement platform; associated surface energy budgets; and the performance of an inferential dry deposition model in predicting deposition velocity (V_d). Fast response O_3, SO_2, and CO_2 instruments coupled with a sonic anemometer were used to derived eddy correlation fluxes for these trace species. A modified Bowen Ratio approach employing filter packs was used to determine HNO_3 flux. Quality control and data assessment procedures are discussed. Flux measurements for O_3, SO_2, and CO_2, are made continuously for up to four months - capturing the total growing cycle for soybeans, a 6-week spring growth spurt for pasture, and a 6-week period of fast growing corn passing to senescence. The major components of the energy budget, ancillary meteorological variables for analysis and modeling, and vegetation parameters, i.e., leaf area index and leaf resistance, were also measured. Fluxes, the energy budget, and observed and modeled V_d are examine for each of the vegetation types, as a function of night and day, and for fast growth and slow growth periods. The magnitude of the fluxes followed the growing cycle with maximum values occurring with fast plant growth conditions and generally large latent heat flux. Measured and modeled O_3 V_d were in agreement for the pasture measurements. Measured O_3 and SO_2 V_d were greater than the model results for corn and soybeans.

COMPARING TURBULENT FLUX MEASUREMENTS OVER GRASS BY EDDY-CORRELATION AND SCINTILLATION

G. Englisch and H. Lohse (GKSS Research-Centre, PO Box 11 60, D-21494 Geesthacht, Germany)

During the ELBDEX96 experiment in Northern Germany extensive measurments of sensible and latent heat fluxes as well as momentum fluxes were carried out. In use were 2 Kajo-Denki Sonics and 2 METEK-USATs for eddy-correlation measurements of the fluxes. Moreover, 2 Scintec SLS-20 scintillometers were operated for the indirect path-averaged determination of sensible-heat and momentum fluxes from the turbulent inner scale length and the refractive index structure parameter.The instrumentation was set up on 4 masts at various heights between 1.5m and 4,5m. Depending on the wind direction the overflown soil conditions changed from fairly wet ground conditions to clearly drier ones. First results on the rate of agreement between the different systems at various wind directions will be presented.

ATMOSPHERIC TURBULENCE WITHIN A SPRUCE STAND: LONG TERM EDDY FLUX MEASUREMENTS ABOVE A FOREST FLOOR

M. Falk, A. Ibrom, K. Morgenstern, I. Richter, G. Gravenhorst (Institute of Bioclimatology, Georg-August University, Büsgenweg 2, 37077, Göttingen, Germany)

Inside a mature Norway spruce stand in the Solling Mountains an eddy correlation system (METEK, USAT-3 and LICOR LI6262) for the measurement of fluctuations of wind speed, temperature, CO2 and water vapour has been operated since June 1996.

The data was used to examine exchange processes and turbulent regime within the forest. A one way rotation was used and a stationarity test was performed on the data with satisfactory results.

The data was intercompared with data from a second eddy correlation unit above the forest canopy and data measured in the summer of 1995 in Sweden above a forest floor during the NOPEX experiment.

ELBDEX96 - COMPARING MICROMETEOROLOGICAL MEASUREMENTS

G. Englisch and H. Lohse (GKSS Research-Centre, PO Box 1160, D-21494 Geesthacht, Germany)

Between July and September 1996 ELBDEX96, an extensive micro-meteorological field experiment, was carried out in the Elbe-river-basain close to Lauenburg/Northern Germany. All parameters which contribute to the energy-balance-equation were measured with various instrumentation. Altogether 6 masts of up to 4.5m height were installed to measure the atmospheric parameters. Moreover, 4 spots were selected for the detection of soil parameters. The experimental site was a 50m wide and 70m long smooth field with high grass, which several times a year is overflooded by the Elbe-river. The experiment's aim was the intercomparison of the systems in order to learn more about their reliability during a long-time-study. First selected results are shown, additionally another attempt to close the energy balance equation is performed.

PARAMETRIZATION OF FLUXES OVER HETEROGENEOUS MELTING SNOW

Richard L. H. Essery (Hadley Centre, UK Met. Office, Bracknell, UK)

A boundary layer model is used to simulate heat and moisture fluxes over heterogeneous melting snow. Results from the boundary layer model are used to assess predictions of area-average surface fluxes and melt rates from two parametrizations of types used in GCM land surface schemes - an 'effective parameter' model which attempts to calculate average fluxes directly in a single calculation, and a 'tile' model which calculates separate fluxes from snow-covered and snow-free fractions of the surface. Both models give reasonable predictions of average fluxes over cold heterogeneous snow, but the tile model gives much better results for heterogeneous melting snow. Tests using a single-column version of the Hadley Centre GCM suggest that the explicit representation of subgrid heterogeneities in snow cover could have a large impact on GCM surface fluxes.

DATA QUALITY ASSESSMENT FOR A LONG TERM EDDY CORRELATION SYSTEM MOUNTED ON A METEOROLOGICAL TOWER ABOVE A FOREST

M. Falk, A. Ibrom, K. Morgenstern, I. Richter, G. Gravenhorst (Institute of Bioclimatology, Georg-August University, Büsgenweg 2, 37077 Göttingen, Germany)

Measurements of the fluctuations of wind speed, temperature, CO2 and water vapour have been made above a mature spruce stand (*Picea abies* (L.) Karst.) of 30m height in the Solling Mountains (Germany) since April 1995. The system uses a METEK 3D sonic anemometer (USAT-3) and a LICOR closed path gas analyser (LI-6262) and has been designed for continuous operation. It is mounted towards the west (the main wind direction) at 39m on a 52m tall meteorological tower. A second 3D sonic anemometer (USAT-3, METEK) was added in June 1996 at the same height facing eastward to investigate tower attenuation effects on the measured quantities. A comparison of turbulent parameters as well as a spectral analysis of power- and cospectra were performed on the raw data of the two systems in regard to directional wind classes. For the standard deviation of the vertical wind an attenuation of up to 40 percent was found when the wind crossed through the tower and spectral comparison showed a dissipation effect for vertical wind fluctuations. Other quantities like the temperature fluctuations showed a different behaviour with less or no dependency on wind direction. Due to the damping of the vertical wind component the net fluxes of the other quantities were up to 30 percent lower. Results were used to develop a correction scheme. (a) A correction function for data acquired earlier was determined. (b) The system set-up was changed to accommodate the need for undisturbed data acquisition from all directions.

COMPARISON OF NEW-TYPE SONIC ANEMOMETERS

Th. Foken, U. Weisensee (German Weather Service, Meteorological Observatory, D-15864 Lindenberg, FRG),
H.-J. Kirzel (METEK GmbH, Fritz-Straßmann-Straße 4, D-25337 Elmshorn)

As part of the LINEX-96/2 field study (Lindenberg area, Germany) a comparison experiment of different types (mostly new) of sonic anemometers was made. The measurements were done over grassland with a fetch of about 150 m at a height of 2 m. Influences of internal boundary layers were excluded. As a standard device the Kaijo-Denki sonic anemometer type DAT-310 with the Probe A was used. The characteristics of the anemometer are well-known from several experiments. The new CSAT3 anemometer from Campbell Scientific and the USA1 anemometer from METEK GmbH were compared against this 'etalon' During the comparison experiment the DAT-310 and CSAT3 anemometers were well orientated into the mean wind direction. Differences in the mean wind speeds were not found. The turbulent parameters like standard deviations and fluxes shows specific differences which will be discussed.

COMPARISON OF THE ENERGY BALANCE OVER A MELTING SNOWPACK AS DERIVED FROM PROFILE AND EDDY-CORRELATION MEASUREMENTS

M. Gempeler (MCR Lab, Department of Geography, University of Basel, Spalenring 145, CH-4055 Basel).
D. Scherer and E. Parlow (Affiliation as above)

During the snowmelt season 1995 both eddy-correlation measurements of turbulent heat fluxes and profile measurements of air temperature, wind speed and relative humidity were carried out in the Kärkevagge, Swedish Lappland. Additionally, short-wave and long-wave radiation fluxes were measured.
By means of the direct turbulent flux measurements, it's possible to compare the results of different profile methods such as Bowen ratio or aerodynamic method and to test their performance. With regard to the observed meltwater production, the importance of the different terms of the energy balance is examined. However, the aim of this part of the investigations is to decide whether comparatively simple profile measurements allow the proper estimation of the energy balance terms under meteorological conditions causing rapid snowmelt. Moreover, advantages and limitations of the applied methods to determine the energy balance over a melting snowcover are discussed.

TWO METHODS OF DETERMINATION OF THE TURBULENT HEAT FLUX FROM ROUTINE METEOROLOGICAL DATA AND THEIR APPLICATION TO CLIMATOLOGICAL PROBLEMS

E.L. Genikhovich and I.G. Gracheva (Both at Main Geophysical Observatory, 7 Karbysheva St., 194021, St.-Petersburg, Russia)
P.Ya. Groisman (National Climatic Data Center, 151 Patton Ave., Asheville, NC 28801, USA

The turbulent heat fluxes at the soil surface are not observed (or poorly observed) by existing observational systems. This affects our ability to reliably predict the consequences of climate changes on the hydrological cycle, to validate corresponding climatic models, and to provide necessary input information for atmospheric dispersion models. Direct measurements of turbulent fluxes in the atmospheric surface layer are available only at a limited number of test sites and for short time periods. Therefore, two methods of determination of the sensible heat flux were developed that utilize the data of routine meteorological observations including, in particular, measurements of the wind speed and air temperature and the temperature of the ground surface. The first method is based on the combination of ideas from the similarity theory and the semi-empirical theory of turbulence. The second method is derived from the similarity theory only. Both methods include description of the "temperature jump" inside the roughness level suggested by Zilitinkevich in 1970. These methods were verified using the data of the observations at Cabauw (the Netherlands), field measurements near Tsimlyansk (Russia), the information from several Russian heat balance stations, and the results presented by Budyko in the Atlas of Heat Balance.

EVAPORATION FROM WELL SATURATED SURFACES DERIVED FROM STANDARD METEOROLOGICAL OBSERVATIONS.

P. Ya. Groisman (NCDC, 151 Patton Ave., Asheville, 28801, USA)
E. L. Genikhovich (MGO, Karbysheva 7, 194021, St.Petersburg, Russia),
V S Golubev (SHI, 2d Line, 199053, St. Petersburg, Russia).

Recently we developed a new method of estimating surface sensible heat fluxes from standard meteorological observations available in many countries throughout Eurasia (e.g., fUSSR, Romania, and China), applied it to studying the snow cover effects on these fluxes, and compared the empirical estimates of these fluxes with the output of several global climate models. Now we discuss our estimates of latent heat fluxes from well saturated surfaces and verify the method by the data of Russian snow evaporation gauges, observations at the heat balance station in subarctic Eurasia, and by the observations at Cabauw, The Netherlands. The analyses of the time series of latent heat fluxes from snow cover over the Northern Eurasia (former Soviet Union) will be presented.

WATER AND CARBON FLUX RELATIONSHIPS - PRELIMINARY RESULTS FROM THE ANCHOR STATION THARANDT

T. Grünwald, M. Berger and Ch. Bernhofer (Institut für Hydrologie und Meteorologie, Technische Universität Dresden, Piennerstr. 9, D-01737 Tharandt, Germany)

Since July 1996 continuous measurements of latent and sensible heat, CO_2 and momentum fluxes by the Eddy-Covariance-Method have been made over a spruce forest at the Anchor Station Tharandt, Germany. These flux measurements using a GILL ultrasonic anemometer and a LICOR 6262 CO_2/H_2O gas analyzer are part of the EUROFLUX initiative to monitor water and carbon fluxes of a variety of temporate forests over a broad range of European climate in a standardized manner. All eddy covariance corrections were performed according to state of art (3-axes rotation, frequency response corrections due to deviations from the *ideal sensor*). A typical dependence of net carbon assimilation to primarily photosynthetically active radiation was found and could be used to fill small data gaps. For July and August 1996 a preliminary result shows a net carbon assimilation of 3000 kg/ha which decreases to 700 kg/ha for October and November. Coupling between latent heat and CO_2 flux can be described as a variation between transpiration and net photosynthesis (acc. to Cowan & Farquhar). The optimum is dependent on meteorological conditions like vapour pressure deficit. A parameterisation of canopy resistance of the combination equation is used to model these relationships in dependence on meteorological variables. Preliminary results will be presented.

Surface-level ozone fluxes onto desert sand

H. Güsten, G. Heinrich, E. Mönnich, D. Sprung, and J. Weppner
(Institut für Meteorologie und Klimaforschung, Forschungszentrum Karlsruhe/Universität Karlsruhe, D-76021 Karlsruhe, Germany

Dry deposition velocities of ozone on soil or bare land, generally used in numerical global or regional models, are taken from data obtained in chamber studies. However, turbulence conditions in the field cannot be truly simulated in a chamber. Since 18 % of all land surfaces on Earth are deserts, there is an interest in quantifying the amount of ozone deposited onto this ecosystem.
Surface-level ozone, the vertical turbulent ozone flux as well as the fluxes of sensible and latent heat were continuously monitored in the Lybian desert, 30 km south of the Dakhla oasis in Egypt from March 23 until April 9, 1993. An automatic station powered by a photovoltaic generator system was used to measure the vertical turbulent ozone flux to the desert ecosystem utilizing the eddy correlation technique. The fairly small ozone fluxes were corrected for effects of micro-turbulent density fluctuations caused by concomittant fluxes of heat and water vapour in the same air volume (Webb correction). While ozone fluxes to the desert ecosystem are below 2 ppb cm s^{-1} in the night, maximum daytime ozone fluxes of 20 ppb cm s^{-1} were measured which yielded a maximum daily dry deposition velocity of 0.15 cm s^{-1}. During the whole measurement campaign of 16 days a mean deposition velocity of V_d = 0.065 cm s^{-1} for ozone is calculated. For global numerical models in which the sources and sinks of ozone in the troposphere are taken into account, a day-time Vd of 0.1 s^{-1} and a night-time value of 0.04 cm s^{-1} are recommended for the desert ecosystem.

First Field Experiments in the Arctic with the Helicopter–Borne Measurement System Helipod

M. Hofmann, C. Wode, and R. Roth,
(Institut für Meteorologie und Klimatologie der Universität Hannover, Herrenhäuser Str. 2, D 30419 Hannover)

Results of measurements with the helicopter-carried turbulence measurement system Helipod are presented. During the expedition ARK-XI/2 of the german RV „Polarstern" in autumn 1995, scientific flight missions were conducted in the Arctic. We present results of measurements of turbulent fluxes derived from both horizontal legs and slanted profiles. The lower horizontal legs were flown in heights of 28, 17, and 7 m asl, respectively. During off-ice air flow conditions, we determined rather low values for the heat fluxes over the open water: 10 to 12 W/m^2 for the sensible and 8 to 10 W/m^2 for the latent heat, respectively. The statistical errors estimated from the integral length scales amount to 1 to 2 W/m^2. From the ascends and descends we determined vertical profiles of turbulent fluxes according to Lenschow et al. (1988) and Tjernström (1993). These profiles were extrapolated to the surface using a simple linear regression. The extrapolated values match well with those derived from horizontal near surface legs.

QUALITY ASSESSMENT AND IMPROVEMENT OF EDDY CORRELATION MEASUREMENTS ABOVE A FOREST CANOPY

A. Ibrom, M. Falk, I. Richter, K. Morgenstern, A. Oltchev, J. Constantin, G Gravenhorst (Institute of Bioclimatology, Georg-August University, Büsgenweg 2, 37077, Göttingen, Germany)

To analyze the annual budgets of energy and matter fluxes above forest eco-systems and the factors controlling the transport rates, continuous long-term flux measurements are conducted currently (e.g. EUROFLUX). Especially in the case of forests, measurements have been performed within the roughness sublayer. In this presentation we discuss methods to assess data quality and develop improvement strategies for these measurements.
Long term observations of CO_2 and H_2O were performed in the roughness sublayer above a mature spruce forest at the Solling mountains in central Germany. Earlier experiments at the same site showed, that the fluxes were invariant with height in a range from 39m to 51m. To reduce fetch requirements we chose the lowest level for our long term investigation. Thus the system had to be mounted aside the tower oriented to the main wind direction. In order to determine fluxes continuously we investigated the tower effect by means of two sonics mounted in opposite directions. A comparison of the used sonic anemometer (USAT-3, Metek) with two other systems lead to further corrections of the fluxes. Correction of these effects improved the data quality considerably. Site specific quality criteria were defined by statistical characterization of turbulence for a period of more than 18 months. Results were compared to other quality criteria (e.g. energy balance closure) to identify their significance for data quality assessment.

COMPLEX TERRAIN SURFACE LAYER PARAMETERS ESTIMATES FOR STABLE CONDITIONS

A. Jaquier, R. Stubi and P. Tercier.
Swiss Meteorological Institute, CH-1530 Payerne, Switzerland.

Sonic anemometers are well-designed instruments for measuring the turbulent fluxes. From those, the critical surface layer parameters, namely the friction velocity, the Obukhov length and the sensible heat flux, are directly available. For an accurate flux determination, the low frequency contributions arising from non-stationary phenomena such as day/night transition have to be removed. Besides, in complex terrain, one has also to deal with the streamlines curvature. In Payerne, a hilly location, after a cross-validation period at 3 meters, operational measurements have been performed using two sonic anemometers at 3 and 30 meters. The method used to take into account the non-stationary behaviours will be presented. The influence of the topography on the measurements will also be discussed. On the other hand, surface layer parameters using models based on the similarity theory have been computed. Their input data additional to the wind profile are the temperature gradient, the cloud cover fraction associated to the global radiation, and the radiation balance. In the comparison between models and measurements, a particular attention has been given to stable cases.

INTERNAL BOUNDARY LAYERS DURING THE LINEX-96/2 FIELD STUDY

O. O. Jegede and Th. Foken (German Weather Service, Meteorological Observatory, D-15864 Lindenberg, FRG),

As part of the LINEX-96/2 field study (Lindenberg area, Germany), the characteristics of the Internal Boundary Layers (IBLs) associated with atmospheric flow across a step change in surface roughness from bare soil to grass, in neutral constant stress layers have been investigated using wind and temperature profiles from a 10 m mast. Estimates of the heights of the IBL were obtained as the intersects of the Monin-Obukhov similarity theory derived wind profiles, from below (<2 m) and above (>6 m) the interface. Values estimated within the periphery of the experimental site compared fairly well with existing theoretical/empirical fetch-height relationships of the form: $\delta = a \cdot x^b$, where a, b are empirical constants. Due to influences of distant obstructions (bushes, scattered trees) that was dominant on the air flow along certain wind directions, the ratios of the friction velocity determined clearly indicated the presence of multiple IBLs in the wind profiles examined which depend on the magnitude of the layer-averaged mean wind speeds.

PROBLEMS IN THE DETERMINATION OF TURBULENT ENERGY FLUXES BY EDDY CORRELATION MEASUREMENTS IN COMPLEX TERRAIN DUE TO WIND FIELD DEFORMATION - A CASE STUDY

O. Kolle, N. Kalthoff (Institut für Meteorologie und Klimaforschung, Forschungszentrum Karlsruhe, Postfach 3640, D-76021 Karlsruhe, Germany)

Long-term measurements of surface energy fluxes were carried out on top of a smooth hill which raises up between 10m and 30m above the surrounding terrain. A sonic-anemometer-thermometer was installed to determine the sensible heat flux and the momentum flux as well as a small tower for the mean profiles of wind speed, temperature and humidity. During two days under clear sky conditions with easterly winds between 5m/s and 9m/s one sharp change in wind direction of about 40 degree was observed. Due to a corresponding slight change in the shape of the upwind terrain the friction velocity and the sensible heat flux measured at 3.5m above ground decreased noticeably as a consequence of the deformed wind field which clearly turns out in the wind profile. Statistical analyses under neutral conditions show a strong dependence between the wind direction i.e. the shape of the terrain and the mean vertical wind component and the friction velocity, respectively. With this information errors in the measured sensible heat flux can be estimated and a correction can be applied to the data. A mean closure gap in the energy balance was found which possibly is related to an underestimation of the sensible heat flux due to the wind field deformation.

MEASUREMENT OF FLUXES OF MOMENTUM, HEAT, WATER VAPOR AND CO2 OVER WATER BY INERTIAL DISSIPATION AND CO-SPECTRAL ESTIMATION.

S.E.Larsen and F.Aa. Hansen Riso National Laboratory, DK-4000 Roskilde, Denmark,
G.De Leeuw and G.J.Kunz TNO-FEL, 2509 JG The Hague, The Netherlands.

Measurements of surface fluxes are often inhibited by flow distortion and, for may trace gas measurements, low sig/noise and fairly low frequency resolution. These constraints are especially important over the sea, where platform obstruction and motion are facts of life, but will also be important for many over land measurements. Presently is described measurements and dataanalysis from the OMEX measurements conducted from ships over the marginal seas of Europe. The fluxes were estimated from the inertial range of the spectra, using the inertial dissipation method, and simultaneously using the low frequency of the flux co-spectra to confirm the estimates. Inherent low signal/noise ratio for the CO2-measurements was improved by cross- correlating the signal from two instruments. Results from the set-up, that has worked well, is presented and discussed.

USING CBL BUDGETTING TO ESTIMATE TRACE GAS FLUXES AND ISOTOPIC FRACTIONATIONS ABOVE A FOREST/BOG COMPLEX IN CENTRAL SIBERIA

J. Lloyd, Australia National University, Canberra, Australia
A Sogatchev, Russian Academy of Sciences, Moscow, Russia
R.J Francey CSIRO Division of Atmopsheric Reserach, Aspendale, Australia
J.N. Byers, Manaaki Whenua - Landcare Research, Lincoln, New Zealand
F.M. Kelliher, Manaaki Whenua - Landcare Research, Lincoln, New Zealand
E.-D. Schulze, Universitat Bayreuth, Germany

Six airplane flights were undertaken above and within the convective boundary layer over a bog/coniferous forest complex in Central Siberia (61 N 90E) in July 1996. As well as continuous measurements of temperarure, pressure, and the concentrations of carbon dioxide and water vapour, about 10 flasks were also filled per flight for measurements of methane, carbon monixide, hydrogen and nitrous oxide as well as for the carbon and oxygen isotopic composition of CO2. Despite considerable input of sensible heat from the forest below, the CBL did grow to more than 1200 m, reaching this height before noon. Available meteorological data suggests that considerable subsidence occurred and this appears to be a regular and widespread phenomenon of this continental region. Substantial changes in the concentration of all gases except N20 occurred near the entrainment zone of the CBL, with differences between CBL air and that of the free troposhere above being as high as 10 ppm for CO2 and 50 ppb for CH4. Regional fluxes were estimated from these profiles and the estimated rates of entrainment and subsidence. The subsidence term was very significant and even resulted in the concentrations of CO2 increasing in the CBL in the afternoons, despite removal of CO2 from the CBL by the photosynthesing vegetation below. Regional estimates of photosynthetic fractionations for carbon-13 and oxygen-18 in CO2 are also presented.

DOME TEMPERATURE AND DIRECT SOLAR INFRARED CORRECTION FOR UNSHADED PYRGEOMETERS

Marty Ch.,Philipona R.,Froehlich C., Physikalisch-Meteorologisches Observatorium Davos, World Radiation Center PMOD/WRC, CH-7260 Davos-Dorf, Switzerland

Equipped with the standard dome temperature measurement pyrgeometers have to be shaded from direct sun. Shading the instrument avoids the inhomogenous heating of the dome. At remote stations, however, common shading systems are inadequate, because they need maintenance and do not work reliably under harsh climatic conditions. Therefore a newly installed radiation network in the Swiss Alps makes use of pyrgeometers with a fixed vertical shadowband. Only at solar noon a uniform shadow casts over the dome independent of the declination. Unshaded operation made it necessary to improve the standard dome temperature measurement. Extended experiments showed that 3 thermistors seperated by 120 degree at 45 degree elevation provide the best results to correct for the thermal emission of the dome in unshaded mode. A common shaded pyrgeometer is also protected from the unwanted inclusion of the infrared part of the direct sun in the measurement, that is part of the shortwave radiation measurement. The fixed shadowband demands a correction for this infrared part of the sun. On sunny days the amount of longwave direct solar irradiance transmitted to the sensor of the pyrgeometers can be easily determined by the solar noon information of the fixed shadowband. This amount depends on one hand on the cut-on of the pyrgeometer dome, which is inherent to the instrument. On the other hand the direct solar irradiance has a local and seasonal dependency (solar elevation, humidity). Detailed results of this correction method will be shown for different stations on different elevation and seasons. They prove the reliable operation of unshaded pyrgeometers. The neglection of this correction produces an error up to 10 W/m2, which can not be omitted if accurate surface flux measurements are needed; especially if a possible increase of atmospheric infrared radiation by a forced anthropogenic greenhouse effect shall be dedected.

FLUX MEASUREMENTS OF AMMONIA, ACIDIC GASES AND PARTICLES ABOVE A HEATHLAND

M.G. Mennen, E.M. van Putten, J. van Hellemond (RIVM, Air Research Laboratory, P.O. Box 1, 3720 BA Bilthoven, The Netherlands)
R.P. Otjes, P. Jongejan, J.J. Møls, G.P. Wyers (ECN, P.O. Box 1, 1755 ZG, Petten, The Netherlands)
E. Nemmitz and M. Sutton (ITE, Edinburgh Research Station, Bush Estate, Penicuik, Midlothian, EH26 0QB, United Kingdom)

Fluxes of NH_3, HCl, HNO_2, HNO_3, SO_2 and acidic particles (sulphate, nitrate, chloride and ammonium) were determined during nearly 4 weeks at the heathland Elspeetsche Veld, located in the centre of the Netherlands, using the gradient method. Concentrations were measured at two (three for NH_3) heights with continuous-flow denuders for the gases and a Steam Jet Aerosol Collector for the particles, both equipped with an Ion Chromatograph and a membrane-diffusion-conductivity system for on-line analysis of sampled extracts. Wind speed, wind direction, friction velocity, specific humidity, temperature, net and global radiation and sensible, latent and soil heat fluxes were measured as well. In addition, particle size distributions were continuously measured with an Aerodynamic Particle Sizer (0.5 - 15 µm) and a Scanning Mobility Particle Sizer (10 - 800 nm) and during some days 12-h average aerosol concentrations and size distributions (five classes) were determined with a Berner cascade impactor. The main aim of the campaign was to study the effects of both gas-to-particle conversion and aerosol dissociation, particularly of volatile ammonium nitrate and ammonium chloride, on the gradients and fluxes.

THE MODELISATION OF THE CARBON, WATER AND HEAT EVOLUTION AND DISTRIBUTION IN A FOREST CANOPY

B. Longdoz and M. Aubinet (Faculté Universitaire des Sciences Agronomiques de Gembloux, 8 av. de la Faculté B-5030 Gembloux, Belgium)
L. M. François (Labo. Phys. Atmos. and Planet., Université de Liège, 5 av. de Cointe B-4000 Liège, Belgium)

The purpose of FOREM (FORest Exchange Model) is to reproduce the variations of different forest pool contents in the carbon, water and energy balances and to predict the fluxes between these pools on a hourly basis. To reach these goals, a mechanistic model is built with three components: the air of the canopy, the vegetation and the soil on a spatial scale of approximately one hectare. The atmosphere and subsoil are the upper and lower boundaries of FOREM. The calibration and validation of this model is performed on measurements taken by M. Aubinet in a beech canopy at Vielsalm (Belgium). This Euroflux site is also equiped with an eddy covariance flux mesurement system that allow us to compare the net fluxes released by the beech canopy with those calculated by FOREM. The objectif of obtaining a validated model forces us to limit the number of pools and the description of fluxes. The first step of this study is the determination of the pool number and flux parameterization most appropriate for the Vielsalm forest canopy. Several parameterizations and schemes are tested, for each components of the hydrological model. The flux estimates resulting from these simulations are compared as much as possible with mesurements.

MEASURING MASS AND ENERGY FLUXES OVER A TEMPERATE BEECH FORESTS: METHODS, PROBLEMS AND RESULTS

G. Matteucci, R. Bimbi, G. Scarascia Mugnozza and R. Valentini (Dep. of Forest Environment and Resources, University of Tuscia, I-01100 Viterbo, Italy)

Since 1991, a long-term monitoring station have been installed in a beech forest in Central Italy (Collelongo, 1500 m a.s.l., 41°52N 13°38E). Structural, micrometeorological and ecophysiological traits have been measured, together with hydrological balance components.
Since 1993, eddy covariance measurement have been performed, using a Gill-Solent sonic anemometer (Gill, UK) and a closed-path IRGA (LiCor 6262, LiCor, USA). Mass (CO_2/H_2O) and energy (sensible and latent heat, net radiation) fluxes have been measured over the forest for almost 2.5 years.

Methods and problems will be discussed with particular regards to: i) technical (hardware, software, etc.) and logistic difficulties in implementing long-term measurements in a remote and mountainous site; ii) problem solving.

Results will be presented in terms of: i) energy balance closure (eddy fluxes and net radiation); ii) quality check of the data (acquisition delay between sonic and IRGA, post-processing of the data, footprint analysis); iii) missing data interpolation; iv) seasonal budget

Hints and highlights will be critically given making profit of this 6 years experience.

COMPARISON OF OBSERVED AND CALCULATED DRY DEPOSITION FLUXES ABOVE PINE FOREST

Róbert Mészáros, Tamás Weidinger (Eötvös Loránd University, Department of Meteorology, Ludovika tér 2, H-1083 Budapest, Hungary)
László Horváth (Institute of Atmospheric Physics, P.O. Box 39, 1675 Budapest)

Spatial and temporal variability of dry deposition of trace gases above different types of vegetation have been investigated in Hungary. Based on 5 field experiments (between 1991 and 1994) carried out over pine forest (Nyírjes, Mátra Mountains, Hungary), the turbulent fluxes and deposition velocities of ozone and sulfur-dioxide have been determined using the gradient method. With the results of this flux measurements the so-called inferential method was tested. In this method the fluxes can be expressed as a product of the gas concentration and the deposition velocity. This latter term can be calculated with a semi-empirical model in which this term is related to different resistances (aerodynamic, boundary layer, canopy resistance). The calculated and measured values of fluxes and deposition velocities were compared for the same time period. The probably explanations of differences and the possibility of application of inferential method above other vegetation types are also analyzed.

A SYSTEM FOR MEASURING FLUXES OF CO_2 AND WATER VAPOUR USING GRADIENT TECHNIQUES - FIRST RESULTS AND COMPARISON WITH EDDY-CORRELATION MEASUREMENTS

K. Morgenstern, C. Schuetz, M. Falk, I. Richter, A. Ibrom, A. Oltchev, J. Constantin, G.Gravenhorst (Institute of Bioclimatology, Georg-August University, Büsgenweg 2, 37077, Göttingen, Germany)

Concentration differences of CO_2 and water vapour were measured above a mature spruce stand of 30m height in the Solling Mountains (Germany). In order to determine gradients of the trace gases in question the system was designed to directly measure their concentration differences with extreme accuracy.
Air is sampled at four levels and sent through four mixing tanks to get a hardware moving time average. The system uses two closed path LI-COR infrared gas analysers (LI-6262), one to determine the concentrations at 45m above ground and the other to simultaneously measure the concentration differences to one of three other levels (30m, 33m, 39m above ground). In this way a maximum of accuracy is achieved. To further minimise errors the LI-6262 is automatically calibrated every 24 hours.
To relate these measurements to the corresponding fluxes eddy-diffusities were calculated from profile measurements of windspeed and temperature taken at the site. Typical CO_2-gradients were about -0.05 ppm/m during the day and 0.01 ppm/m at night. The corrosponding fluxes were -8 $\mu mol/m^2s$ and 2 $\mu mol/m^2s$ respectivly. These results agreed well with eddy-corrolation measurements carried out simultaneously.

SEASONAL VARIABILITY OF THE CO_2 EMISSION AT A SPRUCE FOREST FLOOR: RESULTS OF CONTINUOUS EDDY CORRELATION AND SOIL SURFACE CHAMBER MEASUREMENTS

A.Oltchev, A.Ibrom, K.Morgenstern, D.Fellert, G.Gravenhorst, M.Falk, I.Richter (Institute of Bioclimatology, Georg-August University, Büsgenweg 2, 37077, Göttingen, Germany)

Continuous long-term CO_2 flux measurements at a forest floor in a spruce forest (*Picea abies* [L.] Karst) in the Solling hills (Germany) were carried out: *i*) to study the daily and seasonal cycles of the CO_2 emission and its partitioning at the forest floor, *ii*) to estimate the contribution of the soil respiration in the total CO_2 flux above a spruce forest, *iii*) to compare the CO_2 fluxes measured by eddy correlation and by soil chamber methods, and *iv*) to parameterize the response of the soil respiration rate to changes of environmental conditions. CO_2 fluxes were measured by eddy correlation systems (a 3D-Ultra Sonic Anemometer-Thermometer (USAT-3) combined with a closed path infrared CO_2/H_2O analyser (LI-6262)) on a meteorological tower at two levels (39m and 09m) above and inside a forest canopy, and by a closed soil surface chamber with internal ventilation at a soil surface.
The results indicate a relatively good agreement between CO_2 fluxes measured by eddy correlation within the trunk space and by the soil surface chamber. Contribution of soil respiration in the total CO_2 flux above the forest did not exceed 2.5-3 $\mu mol/m^2s$ over the summer and 0.5-1,5 $\mu mol/m^2s$ during the early spring and late autumn and generally followed changes in soil temperatures. The soil water content during the measuring period was not a limiting factor for soil respiration.

THE KNMI HEXMAX STRESS DATA - A REVISIT

W.A.Oost (Royal Netherlands Meteorological Institute, de Bilt, the Netherlands)

Smith et al. (1992) discussed the wind stress measurements of the 1986 HEXMAX experiment off the Dutch coast, but left some uncertainty about the actual relationship between the stress and the wave field. In this paper we try to find a more definitive answer by looking at the mathematical consequences if we assume the Charnock coefficient to be either a constant or to have an inverse wave age dependence. It turns out that the constant coefficient does not produce coherent results, whereas the inverse wave age dependence does, provided the wave length is not too long. Furthermore an indication is found for an effect of the wave steepness on the stress.

A MEASURE OF INHOMOGENEITY OF THE LAND SURFACE AND PARAMETRIZATION PROBLEMS OF TURBULENT FLUXES IN NATURAL CONDITIONS

G.N.Panin, G.Tetzlaff, A.Raabe, H.-J.Schoenfeldt (Leipzig Institute of Meteorology, Germany).

Measurements of the surface turbulent fluxes (STF) of heat, moisture and momentum in the near-the-surface atmospheric layer by the eddy correlation method and their calculation, rely on the validity of the similarity theory of Monin-Obukhov, which requires stationarity and horizontal homogeneity. Experimental data taken at especially selected sites over land and particularly over sea surfaces allowed to develop this concept.

Recently performed experiments, purposely conducted in non-ideal conditions showed an underestimation of the STF values. Using such experimental data there was shown a corresspondence between turbulent fluxes underestimation and the terrain inhomogeneities. A method is developed for correction of underestimation of turbulent fluxes, a new parameter characterizing the inhomogeneity measure is introduced. Regarding this method should finally bring to the more adequate description of processes on the land surface with the help of mesoscale models and it might prove useful for the design of new validation experiments in non-ideal terrain.

Absolute Calibration of Longwave Radiation Instruments

R. Philipona, Ch. Marty and C. Froehlich, Physikalisch-Meteorologisches Observatorium Davos, World Radiation Center, PMOD/WRC, CH-7260 Davos Dorf, Switzerland.

Longwave radiation instruments, like pyrgeometers, are usually calibrated using the Planck shaped response of black body radiation sources. Results from a recent Round Robin experiment show that calibration coefficients, determined in a number of significantly different black body calibration apparatuses, match consistently within about 1%. Nevertheless, the good agreement of the calibration coefficients for the individual instruments does not necessarily assure correct absolute measurements of the longwave downwelling radiation. Non uniform absorbtivity of the sensor and in particular the unhomogeneous spectral transmittance of pyrgeometer domes can produce a notable bias, when measuring a non Planck clear sky atmosphere with a black body calibrated instrument. The distinctive hemispherical distribution of the longwave radiation flux of a black body radiation source compared to the real sky, measured with a detector with non ideal cosine-law response, produces additional errors. To check the absolute value of pyrgeometer measurements a comparison is made with a windowless pyroelectric radiometer under clear night sky conditions. Sky radiance measurements at a solid angle of six degrees are made at four selected zenith angles. A Gaussian integration method is used to determine the hemispherical downwelling longwave irradiance on a horizontal surface. Pyroelectric detectors are fast, they have very high sensitivity and have an almost flat response up to 25 microns. An absolute cavity radiation source is used to calibrate the pyrolelectric detector. First results of this absolute calibration method will be presented and discussed.

SCINTILLATION CROSSWIND AND TURBULENCE MEASUREMENTS OVER COMPLEX TERRAIN

L. Poggio (Paul Scherrer Institute, 5232 Villigen PSI, Switzerland)
M. Furger and W.K. Graber (Paul Scherrer Institute)

The measurement of atmospheric fluxes over complex terrain is problematic. Representativity and availability must be considered. Use of scintillometers has the advantage to yield integral, remotely sensed measurements of either turbulence parameters or crosswind speed over distances of up to several kilometres. Five scintillometers were used in the valley experiment of the project VOTALP (Vertical Ozone Transport into the Alps). Four instruments were set up across the Mesolcina valley at two different locations and at different heights. One scintillometer was placed along the valley axis in order to measure inside the slope wind zone. Measurements were made in August 1996 over 3 days during a fair weather episode.
As part of the project ECOMONT (Research on Mountain Ecosystems) five scintilometers were deployed in the region of Monte Bondone (IT) in September 1996.

FLOW DISTORTION BY SONIC ANEMOMETERS: COMPARISON OF THREE DIFFERENT TYPES OF SONICS

I.Richter, A. Ibrom, D. Gross, M. Falk, K. Morgenstern, G. Gravenhorst (Institute of Bioclimatology, Georg-August University, Büsgenweg 2, 37077, Göttingen, Germany)

Since April 1995 measurements of wind speed, temperature, CO_2 fluxes and water vapor have been carried out on a continuous basis above a 30m high spruce forest ($d=22.7$, $z_0=2.5$) in the Solling Mountains of central Germany. Wind speed and temperature are measured with a METEK 3D sonic anemometer (USAT-3) at a sampling rate of 10Hz. It is mounted on a 52m high meteorological tower at a height of 39m.
In order to examine flow distortions caused by the probe itself, two other sonics (USA-1, METEK and GILL, Solent 1012R2, Byral), each of them over a period of several weeks, were mounted at the same height close to the USAT-3. As these two probes have a geometric shape which is very different from that of the USAT-3, they are likely to cause less distortion of the wind flow, in particular to the wind flow in the vertical direction. In fact, the results of this comparison show that the values of the mean wind measured by the GILL and the USA-1 were up to 13% and 10% respectively, higher than those measured by the USAT-3. It was examined how the attenuation of the mean wind depends on the horizontal and vertical angle. A scheme has been developed to correct the fluxes measured by the USAT-3.

DETERMINATION OF RADIATION BALANCE COMPONENT AT THE SURFACE USING METEOSAT DATA

A. Rimczi-Pal, I. Dobi, J. Mika, Z. Nagy and R. Randriamampianina (Hungarian Meteorological Service, Gilice tr 39, 1182 Budapest)

Satellite images give opportunity to construct radiation map of better spatial resolution then those derived using only traditional surface measurement. A model calculating the component of radiation balance as global radiation, downward longwave radiation, longwave radiation balance and net radiation balance using satellite images has been developed in the Satellite Research Laboratory of Hungarian Meteorological Service to derive detailed deviation maps of Hungary. In the model the cloud parameters are determined from METEOSAT images moreover radiative transfer model and empirical formule are applied to estimate the surface fluxes. Daily amount of radiation balance components are approximated by statistical method from METEOSAT images received every 3 hours using traditional surface radiation data measured at radiation station Budapest in a 30 year period. In this study the method and a first results of the verification are presented.

SO_2-DEPOSITION INTO A SPRUCE STAND: LONG TERM MEASUREMENTS AND DEPOSITION PARAMETRISATIONS

K.-G. Schnitzler, M. Offermann, H. Kreilein, G. Gravenhorst, S. Mölders
Institute Of Bioclimatology, Büsgenweg 2, 37077 Göttingen, Germany

SO_2 dry deposition is still an important pathway for acidification of sensitive ecosystems. The dry deposition processes of SO_2 to rough surfaces like a forest canopy are not well developed yet for diurnal and seasonal changes.
For a period longer than one year the dry deposition flux of SO_2 to a 110 year old and spruce forest of 30m height in the Solling, middle germany, was monitored using an aerodynamic gradient method. The gradient of SO_2 was derived from five measuring levels above and in the stand by a tube system and two TE43 B/S analyzers.
In addition various micrometeorological parameters as PARadiation, humidity and temperature were measured continously to derive the deposition driving parameters.
The dry deposition velocity ranged between 0.2 and 2 cm/s varying with daytime and seasonal changes.
The stomata resistance ranged between 0 s/m and 100 s/m. The surface resistance ranged between 100 s/m and 650 s/m with a strong influence by humidity e.g. surface wetness.

Canopy Atmosphere Exchange

S. Shen, Dept Earth Sciences, University of Quebec at Montreal, Canada and M.Y. Leclerc, Laboratory for Environmental Physics, University of Georgia, USA

A primary objective of various micrometeorological studies involving vegetation has been to better understand the process of gaseous exchange between the atmosphere and the biologically active canopy. This exchange influences the local weather as well as the climate. Therefore, a knowledge of the gaseous exchange at the canopy-atmosphere interface constitutes also a key aspect in our efforts to improve current climate models. In this paper, the Large-Eddy simulation model was used to simulate the gaseous exchange processes just above and within the canopy. The diffusion of gases from several source configurations within the canopy is modelled and comparisons with experimental data discussed.

EDDY CORRELATION FLUXES OF CO_2 ABOVE A MIXED FOREST CANOPY IN THE CAMPINE REGION IN BELGIUM

N. J. Shurpali (Department of Biology, University of Antwerpen (UIA), B-2610, Wilrijk, Belgium)

R. Ceulemans (Department of Biology, University of Antwerpen (UIA), B-2610, Wilrijk, Belgium)

As a part of the EUROFLUX (EU) project, a field experiment to measure fluxes of CO_2, latent and sensible heat above a mixed forest canopy in the northern part of Belgium is being conducted. The objectives are to 1). perform long term (over a period of 2-3 years) measurements of CO_2, latent and sensible heat fluxes and 2).to determine the sink strength of the forest ecosystem for atmospheric CO_2 and 3). to provide an objective database for models simulating forest growth and primary production. The eddy correlation technique, equipped with a three dimensional sonic anemometer and a fast response infrared gas analyser, is being employed to make flux measurements. The upper-storey vegetation consists mainly of *Pinus sylvestris* and *Quercus robur*, while the under-storey vegetation comprises of *Prunus serotina* and *Rhododendron ponticum*. We present in this paper the results on the CO_2 flux measured during 1996.

CO_2, LATENT AND SENSIBLE HEAT FLUXES ABOVE FOREST CANOPIES IN BELGIUM

Narasinha J. Shurpali (Dept of Biology, Univ of Antwerpen (UIA), B-2610, Wilrijk, BE)

Marc Aubinet (Dept of Physics, Faculté des Sciences Agronomiques de Gembloux, BE)
Reinhart Ceulemans (Dept of Biology, Univ of Antwerpen (UIA), B-2610, Wilrijk, BE)

A thorough knowledge of the forest - atmosphere exchanges of CO_2 and water vapour is crucial to better understand forest growth and the role of forest ecosystems in the global carbon and water balance. Hence there is a need for quantification of surface fluxes from the forest canopies. Quantitative flux estimates along with responses of the various ecosystem processes to their respective controlling variables serve as valuable inputs to scaling models. Considering the heterogeneity evident in European forests, the EUROFLUX project aims to characterise carbon and water vapour exchange from a variety of forest types. With this view in mind, two forest sites were chosen in Belgium - one in Brasschaat in the Campine and the other near Vielsalm in the Ardennes region. *Pinus sylvestris* and *Quercus robur are* the major species at the Brasschaat site, while *Fagus sylvatica, Pseudotsuga menziesii* and *Picea abies* predominate at the Vielsalm site. The fluxes of CO_2, latent and sensible heat are being measured continuously above the canopies employing identical eddy correlation systems. The eddy correlation system at each site consists of a three dimensional sonic anemometer and a fast response infrared gas analyser. Here we compare the results on the CO_2 and water vapour exchange from the two forest sites during 1996.

AN EXPERIMENTAL STUDY OF SURFACE TRACE GAS FLUXES IN THE COMPLEX TERRAIN OF SWITZERLAND AND THEIR CORRELATION TO VERTICAL CONCENTRATION AND FLUX PROFILES IN THE PLANETARY BOUNDARY LAYER

F. Siegrist & W. Eugster (Institute of Geography, University of Berne, Department for Climatology and Meteorology, Hallerstr. 12, CH-3012 Berne, Switzerland)

In complex terrain removal and emission of trace gases at the soil-vegetation-atmosphere interface influence the concentration profiles in the atmosphere above the surface in a different way than over flat and homogeneous surfaces. It is aimed to investigate how vertical concentration gradients in the planetary boundary layer and the associated flux divergence relate to surface fluxes measured by micrometeorological techniques.
The experimental concept assesses the volume flux budget of the air volume between the complex surface topography and the top of the planetary boundary layer over the Swiss Plateau. Eddy correlation flux measurements at the surface are combined with tethered balloon profile soundings using the continuity equation for scalars in the atmosphere.
Results from the first intensive measuring campaign during the Swiss BAT project (= Regional Budgets of Atmospheric Trace Gases) in summer 1996 are presented. The region chosen for these measurements is the 'Seeland', the largest flat rural area on the Swiss Plateau, which has a complex landuse structure. Future BAT campaigns are scheduled for 1997 and 1998.

THE MODEL OF MESOSCALE METEOROLOGICAL REGIME FOR THE FOREST AREA

A. Sogachev (Sukachevs laboratory of Institute of Evolution and Ecology Problems, RAS, Leninskij pr. 33, 117071, Moscow, Russia)
G. Menzhulin (State Hydrological Institute, 2-line V.O. 1, St. Petersburg, Russia)
G. Gravenhorst (Institute of Bioclimatology, Georg-August University, Büsgenweg 2, 37077 Göttinget, Germany).

The specialised model for energy and mass exchange in horisontally heterogenious vegetation canopy and in atmospheric boundary layer above it is presented. This model based on the well-known hydrothermodynamic equations and justified parametrisations is able to adequately reproduce the main regularities of turbulent flow. Also the solar radiation, heat and water vapour transfer submodels are included in mesoscale model. The developed model has been tested with several numeric experiments as applied to one, two and three dimensional cases of turbulent flow in the atmospheric layer above the surface of forest area. The model describes the horizontal distribution of vertical velosity and turbulent energy over the forest in Solling region (Germany) rather realistic. The numerical experiments show the increasing of turbulent energy near the borders of the various vegetation in Solling region also very realistic.

TURBULENT EXCHANGE ABOVE DIFFERENT CANOPIES

M.R. Soler, P. Buenestado (Dpt. Astronomia i Meteorologia, Universitat de Barcelona, Avda. Diagonal 647, 08028 Barcelona, Spain)
L. Conangla, E. Ferreres (Dpt. Fisica Aplicada, Universitat Politecnica de Catalunya, 08028 Barcelona, Spain)

The aim of this work is to study the turbulent exchange between the atmosphere and the underlying surface. We have considered three types of surfaces, irrigated agricultural area, dry cereal agricultural area and non agricultural dry area. The values of the surface turbulent fluxes based on Bowen ratio-energy balance and similarity theory of Monin Obukhov methods are calculated continuously since October 1996. In determined conditions these values are compared with those obtained by the eddy correlation system. The results obtained allow us to compare the agreement between calculated and measured fluxes by different methods, to investigate the effect of the location and type of surface and the influence of meso and synoptic scales on the surface fluxes.

MICROMETEOROLOGICAL INVESTIGATIONS OF TRACE GAS FLUXES AT THE SOIL-VEGETATION-ATMOSPHERE INTERFACE

F. Siegrist (Geographical Institute, University of Berne, Departement for Climatology and Meteorology, Hallerstr. 12, CH-3012 Berne, Switzerland)

BAT is a project focussing on the dynamic exchange processes of nitrogenous and other trace gases at the soil-vegetation-atmosphere interface in rural areas. The first intensive measuring campaign was held in summer 1996 in the Swiss Seeland region, the largest flat rural area on the Swiss Plateau, more campaigns are planned for 1997 and 1998. The chosen site consists of an interesting inhomogenity as far as landuse is concerned. As inhomogenous terrain is typical for Switzerland, it is an important aim of the project to find reliable investigation methods for measuring fluxes under such conditions. The presented poster treats the following issues: improvement of eddy correlation measurements of micrometeorological and trace gas fluxes; combination of near surface flux measurements and vertical tethered balloon profile soundings using the theoretical approach of the ground based thermodinamic energy equation method; vertical flux divergences of trace gas fluxes above inhomogenous terrain.

PROBING THE SURFACE STABLE BOUNDARY LAYER

M.R. Soler, P. Buenestado (Dpt. Astronomia i Meteorologia, Universit at de Barcelona, Avda. Diagonal 647, 08028 Barcelona, Spain)
L. Conangla, E. Ferreres and J. Vilà (Dpt. Fisica Aplicada, Universitat Poli tecnica de Catalunya, 08028 Barcelona, Spain)

Surface mean and turbulent measurements were taken under strong stable conditions at Tarragona (Spain) during five days. These observations were complemented with wind and temperature vertical profiles collected by means of a threemonoestatic acoustic sounder and a tethere d balloon. In order to detect the presence of gravity waves, three microbarographs were located at the experimental site, in the stable layer under study. Although the final data set consists of few points, general agreement is found with similarity theory. The spectral analysis showed a well defined inertial subrange.

Long-term measurements of the turbulent vertical ozone flux onto a field of barley

D. Sprung, H. Güsten, and G. Heinrich (Institut für Meteorologie und Klimaforschung, Forschungszentrum Karlsruhe/Universität Karlsruhe, D-76021 Karlsruhe, Federal Republic of Germany)

A robust and light-weight ozone sensor was used successfully in continuous measurement of the eddy flux over a barley field from April until August and over the same flat harvested field from the beginning of August until the end of September 1992. The measuring site near Bellheim (49°10'33"N, 8°16'35"E) in south west Germany is located on a flat agricultural terrain (elevation 130 m) of approximatley 3 x 4 km^2 in the Upper Rhine Valley providing a considerable homogeneous fetch of more than one kilometer upwind of the measuring tower. A total of 2658 half-hourly mean values of the turbulent ozone flux were obtained continuously throughout the half year using the eddy correlation technique. A statistical evaluation of the ozone fluxes divided into weakly mean periods provided the following information:

- The maximum weekly ozone fluxes onto barley vary by a factor of 3 (23 - 69 ppbv cm s^{-1}). The lowest and the highest weekly maximum values of the ozone fluxes were measured in two consecutive weeks in July which indicates the strong influence of the weather on the ozone deposition flux,
- the weekly mean deposition velocities of ozone over the entire measurement period vary from 0.16 to 0.35 cm s^{-1},
- the largest values of the mean weekly ozone fluxes over the entire measurement campaign were obtained in June during the period of strong increase in plant growth (30 to 85 cm) as well as that of the leaf area index (1.5 to 7).

RESISTANCES TO OZONE DEPOSITION TO AN ARCTIC AAPA MIRE

J.-P. Tuovinen, **M. Aurela** and T. Laurila (Finnish Meteorological Institute, Air Quality Research, Sahaajankatu 20 E, FIN-00810 Helsinki, Finland; juha-pekka tuovinen@fmi.fi)

Ozone deposition and related turbulent fluxes were measured by the eddy covariance method on an open flark fen in Northern Finland (69°08'N, 27°17'E), 200 km north of the Arctic Circle. The campaign period (15 Aug. to 13 Sept. 1995) extended to the decline of the growing season. The fen comprises patches of open water, hummocks covered by mosses and shrubs, and wet sedge-vegetated hollows, as typical for the northern aapa mire zone. Low deposition velocities of ca. 0.2 cm s^{-1} with a weak diurnal variation were measured for ozone. The fluxes were interpreted in terms of a common big-leaf resistance model. When a molecular resistance parametrisation derived for vegetated surfaces was applied, the residual bulk surface resistance exhibited an apparent dependency on the flow. This was taken as an indication of bluff-body nature of the hummock-hollow surface, which adds to the uncertainties in determining the surface resistance. The non-stomatal pathways seemed to dominate the surface resistance, and no correspondence with the damping of the stomatal exchange was observed.

TOWARDS A TRACEABLE MEASUREMENT OF NET RADIATION

R.Vogt, Chr. Feigenwinter, E. Parlow (MCR Lab, Department of Geography, University of Basel, Spalenring 145, CH-4055 Basel)

In surface energy balance studies there often appears a closure gap: the measured turbulent fluxes of sensible and latent heat do not sum up to the available energy, consisting of net radiation and storage fluxes. This presentation discusses the contribution of the measurement of net radiation to the energy balance closure problem, especially in the light of a lacking standard for calibration. Results are reported from two experiments, where three types of net radiometers (6 Schulze-D=E4kc, 40 Schenk Mod. 8111, 1= REBS Q7.1) are compared to a new reference consisting of a combination of two pyrgeometers (Eppley PIR) and two pyranometers (CM21, CM11). The instruments (except CM11) were calibrated at the World Radiation Center, Davos, where also the dome temperature measurement of the pyrgeometer was modified. Using the factory calibration for the Schenk pyrradiometers, the differences ranged between -8 and +20 %. During night time the magnitude of net radiation was underestimated up to 30 %. The adjustment to the reference measurement can be done within =B15% or =B115Wm-2, whichever is largest. The assessment of the closeness of the measured net radiation to the true value is still a difficult task, but it can be stated, that the large closure gaps in the range of 20 to 50 % of the available energy, as reported in many studies, are in general not due to uncertainties in measured net radiation.

TURBULENT FLUXES ABOVE A SPRUCE CONOPY

M. Winterhalter and P. Fabian (Lehrstuhl für Bioklimatologie und Immissionsmessung, Hohenbachernstr. 22, D - 85354 Freising, Germany)
G. Enders (Meteorologischen Institut München, Theresienstr. 37, 80333 München)

Annual variation of turbulent fluxes (momentum, latent and sensible heat, ozone) above a spruce canopy are presented. The gradients of the important variables are measured at a tower in 5 levels above then canopy (28 m height) with a frequency of 0.1 Hz. Eddy - correlation system run with a measurement frequency of 10 Hz at the same site in 41 m above the ground. It indicates that the turbulent fluxes are highly determined by the right choose of the time intervall. Therefore the convergence of the fluxes must be tested. Applying the Monin - Obuchov theory, the convergence of the calculated fluxes must also be analysed. The ozone fluxes must be corrected because of chemical reactions. The results for different time intervalls are compared with fluxes derived from constant time intervalls of 1/2 hour and with fluxes derived from the Bowen ratio.

A RELAXED EDDY ACCUMULATION SYSTEM FOR VOLATILE ORGANIC COMPOUNDS

R. Valentini, (Dep. of Forest Environment and Resources, University of Tuscia, I-01100 Viterbo, Italy), P. Ciccioli (CNR - Institute for Atmospheric Pollution, Montelibretti, Italy), G. Seufert (JRC, European Commission, Ispra, Italy).

A system for measuring Volatile Organic Compounds (VOCs) emitted by vegetation canopies has been developed. The system here presented is constituted by traps of adsorbant material (Carbon or Tenax) placed at the inlet of the two sampling lines, thus avoiding potential problems of time lag calculations and contamination of the reservoirs.
A software was developed for on-line calculation of the semi - empirical coefficient for the application of the relaxed tchory, based on the temperature time series and the sensible heat eddy flux measurements. Theorethical considerations on the methodology and the parctical applications are presented.

ON THE VARIATION OF THE ENERGY-BALANCE COMPONENTS IN THE REKLIP AREA

A. Wenzel, N. Kalthoff, F. Fiedler, O. Kolle, M. Kohler (Institut für Meteorologie und Klimaforschung, Forschungszentrum Karlsruhe, Postfach 3640, D-76021 Karlsruhe, Germany)

Within the framework of REKLIP (Regio-Klima-Projekt) performed in the Upper Rhine Valley and the surrounding mountains 36 meteorological stations were installed at different altitudes, in order to investigate the climatic state and the energy balance with high temporal and spatial resolutions.The main results are: (i) an evaporation increase in the Rhine Valley between northerly stations and southerly stations was found, although there is only a small difference in altitude between the stations. The increase can be related to the increase in precipitation. Nearly a constant ratio of 0.8 between the evaporation and the precipitation is given. The higher precipitation can be related to a remote effect of the orography, because the southerly stations are situated in the luff of higher mountains. (ii) the increase in the sensible and the decrease of the latent heat fluxes with the altitude at the slope of the Black Forest, although there is a strong increase in precipitation from the Rhine Valley (880 mm y^{-1}) to the Black Forest (1340 mm y^{-1}). Explanation for this behaviour can be given from the relation of the temperature gradient to the moisture gradient. In order to receive the energy balance for the REKLIP area with higher spatial resolution instead of point measurements, a set of equations was derived. It can be proved that these equations reproduce the measured behaviour of the energy balance in the REKLIP area.

ST18/OA12 Open session on turbulent boundary layers
03 Atmospheric boundary layer studies

Convener: Hojstrup, J.
Co-Conveners: Corsmeier, U.; Seibert, P.

A MODEL FOR THE BOUNDARY LAYER CLOUDS USING SECOND ORDER TURBULENCE CLOSURE

K. Abdella and N. McFarlane, Canadian Centre for Climate Modelling and Analysis, Victoria, British Columbia, Canada

We present a second order turbulence model for the planetary boundary layer(PBL) which is extended for application of a statistical scheme of the subgrid-scale condensation. The model contains a prognostic equation for the turbulent kinetic energy. The other second order moments modelled through the parameterization of the third order moments which are obtained through a convective mass-flux argument. For the heat flux this leads to a formulation with the usual down-gradient term and a countergradient term. The effect of the turbulence scheme on the partial cloudiness scheme will be discussed and the performance of the model is tested by considering different cloudy PBL conditions and comparing the results with observed reference cases. The model produces the mean as well as the turbulent quantities that are in a reasonable agreement with the observational data.

EXPERIMENTAL METHOD OF ACOUSTIC TOMOGRAPHIC MONITORING OF THE ATMOSPHERIC SURFACE LAYER

K. Arnold, A. Ziemann, A. Raabe (Institute of Meteorology, University Leipzig, Stephanstr. 3, D-04103 Leipzig, Germany)

Acoustic tomography is proposed as a method for remote monitoring of atmospheric variables. An experimental method is presented which provides volume averaged values of meteorological parameters.
In such a system, a number of sources transmit at the same time an acoustical signal which are detected at a number of receivers. The sources and receivers were positioned at an array of 100×200 m. By monitoring the travel time of an sine wave (500 Hz) between each possible source-receiver pair a volume is spanned by a number of acoustic paths. The distances between the speakers and microphones were determined with a very high precision so that the measured travel time gives the sound speed as an answer.
Travel time measurements were inverted to obtain estimates of the relevant meteorological parameters.
Improvements over traditional in situ methods are e.g. that the sensors need not be located at the field point being measured and more data points per sensor can be generated than by traditional techniques.
Experimental estimated values for meteorological parameters such as temperature and wind velocity in different levels are used for the validation of the tomographic models .

VERTICAL TRANSPORT PROCESSES IN THE ATMOSPHERIC BOUNDARY LAYER

U. Corsmeier, N. Kalthoff, M. Kotzian (Institut für Meteorologie und Klimaforschung, Forschungszentrum Karlsruhe/Universität Karlsruhe, Postfach 3640, 76021 Karlsruhe, FRG)
M. Krautstrunk, G. Neumann-Hauf, H. Schlager (DLR, Institut für Physik der Atmosphäre, 82234 Oberpaffenhofen, FRG)
O. Klemm (Universität Bayreuth, BITÖK, 95440 Bayreuth, FRG)
F. Beyrich (Lehrstuhl für Umweltmeteorologie, BTU Cottbus, Postfach 101344, 03013 Cottbus, FRG)

In 1994 the field campaign SADE94 (SANA deposition experiment) was conducted in the five new federal states of Germany to study among others the vertical mixing of air pollutants in the convective planetary boundary layer (PBL) over a homogeneous surface near the small saxon village Melpitz. Using a radiosounding system, a tethered ballon and a sodar system, the temporal development of the PBL was analysed at October 11, 1994. Airborne measurements of meteorological parameters and chemical spezies like SO_2, NO, NO_2 and O_3 were made twice a day, in the early and late afternoon, by the research aircraft DO 228 of DLR, operating along eight horizontal flight legs between 150 m agl and 1000 m agl above the ground station. Organized updrafts of about 800 m diameter, polluted with NO_y, and compensating downward motion were detected in the upper PBL. A wavy structure of polluted air originating from the PBL and clean air from the capping inversion was found at the interface between PBL and capping inversion.

MODIFICATION OF FLOW OVER COMPLEX TERRAIN BY CHANNELLING AND LEE-EFFECTS

U. Corsmeier, U. Rummel (Institut für Meteorologie und Klimaforschung, Forschungszentrum Karlsruhe / Universität Karlsruhe; Postfach 3640, 76021 Karlsruhe, FRG)

In the 1992 field campaign REKLIP (three nation REGIO-KLIMA-PROJEKT of Germany, France and Switzerland) the influence of complex terrain on the flow within the boundary layer was investigated in the Rhine Valley during a high pressure situation in winter with northeasterly flow. In the valley, surrounded by the Black Forest and the Vosges mountains, often secondary circulation systems appear, driven either by thermal effects or by dynamic effects caused by flow over or around mountain ridges. Observations are presented with special emphasis on the concurrence of different secondary flow systems across the valley near Strasbourg. Channelling causes a turning of the wind direction from NE above the valley to NNE in the northern part of the Rhine valley. But in the lee of the mountain Hornisginde (1163 m), at the eastside of the valley the wind in the lower 400 m above ground blew from SSW, 180 degree opposite to the flow in the western part of the valley. Beside the stable stratification and the surface pressure gradient in the valley the phenomenon is caused by flowsplitting around the Hornisgrinde due to low Froude numbers. It is shown, that the flow over the mountain causes a wavy structure in the inversion layer downstream at the leeside, while flow around the mountain is responsible for the reverse flow at the valley bottom.

ON A ROLE OF REMOTE SENSING AND SYNOPTIC ANALYSIS IN THE ABL MIXING MECHANISMS STUDY AND MODELING

M.A. Kallistratova*, I.V. Petenko*, S.D.Danilov*, M.A. Lokoschenko^
*Inst. of Atmospheric Phys. of RAS, Pyzhevski per.3, Moscow Russia
^Geograph. Dept of Moscow State University

Study of the atmospheric boundary layer (ABL) behaviour is two-folded problem. Its first side is dictated by current needs that ensue from the modelling possibilities. The second one is connected with physics of the ABL itself. Better understanding of main mixing processes in it may not immediately lead to new practical results, but in future it will result in improved models. The remote sensing technique (especially sodar and lidar) gives besides quantity data the unique possibility to visualise the structural nature of the ABL and reveal the great diversity of shapes and space-time distributions of long-living organised structures. Analysis of the vast remote sensing data, combined with analysis of synoptic and orographic factors is carried out. Description, classification and an attempt of physical explanation of the typical structures and their evolution are made. Statistical data on frequency of different types of the structures under different seasons, synoptic conditions, terrain type and bed surfaces are presented. Some discrepancies between observed ABL structure and widespread ABL models are demonstrated.

OROGRAPHICALLY INDUCED SECONDARY CIRCULATIONS IN THE AREA OF FREIBURG-SCHAUINSLAND

N Kalthoff, V. Horlacher (Institut für Meteorologie und Klima-forschung, Forschungszentrum Karlsruhe, Postfach 3640, D-76021 Karlsruhe, Germany), P. Thamm (Institut fur Physische Geographie, Universität Freiburg)

Complex terrain structure often leads to the development of secondary circulation systems Additionlly, the mixed layer depth shows a strong spatial variation. Both, the secondary circulations and the varying mixed layer depth lead to horizontal transport and vertical diffusion of air pollutants which are different from those over homogeneous terrain. The area of Freiburg-Schauinsland has such a complex terrain structure with mesoscale mountains and valleys. In summer 1996 an experiment was performed to study the evolution of secondary circulation systems and boundary layer heights. Therefore, several surface stations, two tethersonde stations, one radiosonde station and two sodar systems were installed. In order to analyse the influence of the meteorological conditions on the concentrations the surface stations were equipped to measure O_3, NO and NO_2,. It was found that in the Kirchzartener Valley - even under convective conditions - a mixed layer height of only a few hundred meters established. This low mixed layer was caused by the change from mountain to valley winds and the accompanied cold air advection from the Rhine Valley into the Kirchzartener Valley. The low mixed layer height reduces vertical mixing significantly. The onset of the valley wind also is accompanied by an increase of air pollutants transported from the highly industrial areas of the Rhine Valley to the mountain sites.

CLOSURE OF LOCAL TURBULENT TRANSFER MODELS FOR ATMOSPHERE USING OPERATIVE MEASUREMENTS DATA

V.Kramar (Inst. of Atmospheric Phys. of RAS, Pyzhevski per.3, Moscow, Russia)

(1) To solve the above problem connected with models of local area transport of pollutants, nowcasting and very short range forecasting of pollutants distribution in the atmospheric boundary layer (ABL) it was proposed to use data of uninterrupted measurements of the ABL parameters by sound locator (sodar). The information obtained with the sodar data analysis describing vertical distributions of parameters of current state of ABL and its history in the point of a unit location may be used in the models instead of mean values of the "empirical constants" and pre-calculated vertical distributions. Conditions and limits of the method applicability are discussed. (2) Simple semi-empirical model of turbulent transfer in terms of turbulence kinetic energy, eddy viscosity, turbulence scale was selected to show the method potentials. The model degenerates for the lower layers. That gives the possibility to determine from the sodar data values of some model constants valid for the whole ABL. Then vertical distributions of turbulence parameters were calculated using sodar data vertical profiles. (3) These characteristics of the ABL obtained in the ARAL-92 expedition were used as the empirical material. The material is: instantaneous profiles stored continuously by a 3-component doppler monostatic sodar representing values of three components of wind velocity and Ct2 parameter up to the heights of about 300m. The experiment was carried out on the dry bed of the Aral Sea in the moving sand zone in conditions of high horizontal uniformity and low roughness. Some episodes of dust storms were registered. (4) The vertical distributions calculated are presented.

NON-ISOTROPIC TURBULENCE IN THE MARINE ATMOSPHERIC BOUNDARY LAYER DURING THE SEMAPHORE EXPERIMENT.

D. Lambert, P. Durand, B. Bénech and A. Druilhet (LABORATOIRE D'AEROLOGIE UMR CNRS/UPS 5560)

The SEMAPHORE experiment was conducted in the Azores region during fall 1993. Several survey missions were carried out by two French aircraft, instrumented to measure "in situ" the turbulence structure of the Marine Atmospheric Boundary Layer (MABL) in the open ocean. The flights plans included several 30 to 200km long horizontal legs, along and across the mean wind direction at different altitudes. The statistical analysis of the collected data clearly demonstrates the anisotropy of the horizontal structure of the turbulence intensity, featuring an elongated shape in the direction of the mean wind. The values of turbulence moments depend on the sampling direction and fluxes along the wind direction can be underestimated by 20 to 30 % .

DIURNAL EVOLUTION OF COHERENT STRUCTURES IN THE PLANETARY BOUNDARY LAYER (TRAC EXPERIMENT)

F. Lohou, A. Druilhet and B. Campistron (Laboratoire d'Aérologie, UMR 5560, OMP, 14 Avenue E. Belin, 31400 Toulouse, France)

The Planetary Boundary Layer (PBL) has been considered for a long time as made of homogeneous and isotropic turbulence. This hypothesis allows to use a statistical method which has conducted to a turbulent parameterization used in numerical models. This approach does not take into account coherent structures such as cells and horizontal rolls vortices. These organizations of the convection in the PBL feed the turbulent motion and at a larger scale participate in the vertical exchanges and so modify the energy budget. The study of the coherent structures and their role in the energy transfer in the PBL was the scientific goal of the TRAC experiment (Turbulence-Radar-Aircraft-Cells), conducted in France in june 1993 over a homogeneous and flat area during anticyclonic situations. Two complementary measurements were used, in situ measurements with an instrumented aircraft and the 3-dimensional view of a C-band Doppler radar. A method based on the two-dimensional autocorrelation of the horizontal reflectivity planes brings out the main mode of the coherent structures which appeared every day during the experiment. These organizations, evolving during the day between cells and rolls, were related to the dynamics and thermodynamics characteristics of both PBL and free atmosphere which can affect the PBL through the cloudy layer.

PARAMETERIZATION OF CLOUD AT LOCAL SCALE

Esmaiel Malek, Department of Plants, Soils and Biometeorology, Utah State University, Logan, Utah 84322-4820, U.S.A.

Research has been conducted in Logan, Utah, U.S.A., since October 1995 to measure radiative fluxes, temperature and moisture near the ground to parameterize clouds at local scale in this semi-arid mountainous valley. We are using two Kipp & Zonen CM11 pyranometers (one inverted) to measure the incoming and outgoing solar (shortwave) radiation, respectively; and two Kipp & Zonen CG1 pyrgeometrs (one inverted) to measure the incoming (atmospheric) and outgoing (terrestrial) longwave radiation, respectively. These instruments are equipped with Kipp & Zonen CVB1 blowers powered by CVP1 units (if necessary) to prevent precipitation of dew and frost which otherwise would disturb the measurement. Wind speed and direction, and precipitation are also measured. All these parameters are measured every 5 seconds and averaged into 20 minutes intervals during all weather conditions and stored in a data logger.

The preliminary results indicate that the atmospheric radiation measured by pyrgeometer during cloudless skies was almost identical with the one computed by Brutsaert's formula (using the 2 m air temperature and moisture). During cloudy skies, the incoming longwave radiation measured by pyrgeometer is greater than (depending on the cloud type and degree of cloudiness) that computed for the cloudless skies. The additional longwave radiation during the cloudy skies comes from clouds in the waveband which the gaseous emission lacks, e.g. from 8-13 μm (the so-called atmospheric window). Based upon the surface thermodynamic conditions we have parameterized clouds (cloud base temperature, cloud base height, and cloud coverage) at local scale.

ON THE SENSITIVITY OF FLUXES TO TYPE A AND TYPE B LAND SURFACE COVER

Nicole Mölders (LIM - Institut für Meteorologie, Universität Leipzig, Stephanstraße 3, D-04103 Leipzig, Germany)

The atmospheric response to type A and B land surface cover in the hierarchy of Shuttleworth (1991; Surv. Geophys. 3-30) is investigated by comparing results provided by a meso-β-scale meteorological model with and without consideration of subgrid-scale heterogeneity by an explicit subgrid scheme. In the simulation without the explicit subgrid scheme the dominat landuse type within a grid cell is used to calculate the water and energy fluxes, for which the patches of homogeneous landuse extend several grid cells and can be regarded as a type B land surface cover. The landscape represented on the explicit subgrid corresponds to a type A land surface cover. Six degrees of subgrid-scale heterogeneity with respect to the landuse are distinguished. The obtained changes in cloud structures, precipitation pattern and intensity, evapotranspiration and soil wetness were closely related to the degree of subgrid-scale heterogeneity. Physical heterogeneity within a grid cell, i.e., that of the surface temperatures and soil wetness, which results from the subgrid-scale heterogeneity, enhance the differences, especially, if precipitation occurs. The local recycling of water decreases with increasing degree of subgrid-scale heterogeneity. Consequently, broken cloud fields and a shower-like precipitation form for heterogeneous areas. Hence, the physical patchiness of surface quantities going along with a higher degree of heterogeneity seems to contribute to the persistence and the enhancement of the physical heterogeneity. On the contrary, the type B land surface cover tends to continuously provide water to the atmosphere yielding to a stratiform cloud and precipitation distribution and less physical heterogeneity.

1D-MODELLING OF ATMOSPHERIC VERTICAL EXCHANGE PROPERTIES WITHIN AND ABOVE A SPRUCE FOREST WITH TRANSILIENT TURBULENCE THEORY

E. Nützmann, J. Constantin, A. Ibrom, H. Witte - Gaedecke, H. Kreilein, G. Gravenhorst (Institute of Bioclimatology, Georg-August-University, Büsgenweg 2, 37077 Göttingen, Germany), G. Inclán (Institute of Meteorology, University of Munich, Theresienstr. 37, 80333 Munich, Germany), W. Mix (Humboldt-University., Institut of Physics - Meteorology, Müggelseedamm 256/58, 12587 Berlin, Germany)

To quantitatively describe deposition- and emission rates of atmospheric trace gases for forest ecosystems and soils by profile measurements it is necessary to model the turbulent exchange properties of the atmospheric boundary layer above and within the forest canopy.
This report explores the turbulent exchange between layers within and above a forest by means of the transilient turbulence approach. The numerical model is based on the boundary layer model structure and the parameterisations of energy transfer processes at the phytoelements (MIX et al. 1995) and is using the transilient turbulence approach extended to forest canopies (Inclán, 1996). The biometric properties of the spruce stand at Solling Mountains and the measured profiles of temperature, specific humidity and horizontal wind speed are parameters to derive a transilient matrix for this site. Simulated vertical fluxes of H_2O, heat and momentum are compared with eddy correlation measurements. Measured counter gradient vertical fluxes within the trunk space are reproduced by transilient approach. Furthermore the transilient exchange matrix is discussed as a tool for deriving statistical properties of the turbulent exchange within and above a tall forest stand.

THE USE OF KITES TO STUDY THE ANTARCTIC BOUNDARY LAYER.

M. J. Varley and P.S. Anderson.
British Antarctic Survey, High Cross, Madingley Rd, Cambridge, CB3 0ET, UK.

A system for profiling meteorological variables in the Antarctic is described. Kites are employed as a method of raising and lowering measuring equipment. Two separate experiments are examined. The first involves installing a static site at the British Antarctic Survey's Halley Research Station capable of allowing year round profiling up to 1000 m. With this system regular, high resolution monitoring of the Antarctic stable boundary layer is possible as well as other studies such as calibrating the radiosonde ascent data taken daily at the station and also calibrating data from a SODAR which is soon to be installed at the station.
The second involves profiling at remote site on the continental slope margin in Coats Land south-east of Halley with a lightweight, highly portable profiling system capable of taking measurements up to 500 m. Investigation here is of the mesoscale drainage and katabatic flow evolution occuring along the continental/shelf ice interface.These measurements will be combined with data from a transect of AWSs ascending the Coats Land continental slope as part of CLAMP (Coats Land Mesoscale Project).

NUMERICAL MODEL OF ACOUSTIC TOMOGRAPHY INSIDE THE ATMOSPHERIC SURFACE LAYER

A. Ziemann, K.Arnold, A.Raabe (Institute of Meteorology, University Leipzig. Stephanstr. 3, D-04103 Leipzig, Germany)

Theoretical estimations will be presented which direct provide volume averaged values of meteorological parameters (air temperature) by means of acoustic remote sensing and so deliver rather consistent data for validation of numerical atmospheric models.
The procedures use horizontal propagation of acoustic waves in the atmospheric surface layer. From measurements of acoustic parameters (travel time in our case) with transmitters and receivers on different places in an array of 100×200 m over grassland the state of the crossed atmosphere can be estimated. Derivation of volume averaged values results from invertation of single values of the selected acoustic parameter (acoustic tomography). An increased number of sources and receivers improve resolution of the measuring field.
For the development of experimental methods the demanded resolution for measurements of travel time is very important in order to determine volume averaged values for meteorological parameters with sufficient accuracy (temperature: 0,2 K).
Sound propagation in a turbulent atmosphere can be studied by coupling atmospheric models with ray-tracing models. The simulated acoustic parameter values will be compared with experimental values for sound propagation and thereby measurement errors and the influence of atmosphere and soil conditions can be calculated

A COMPARISON OF PRACTICAL METHODS FOR THE DETERMINATION OF MIXING HEIGHTS

Petra Seibert (Institute of Meteorology and Physics, Agricultural University (BOKU), Türkenschanzstr. 18, A-1180 Vienna, Austria; email: seibert@mail.boku.ac.at); F. Beyrich (BTU Cottbus, Germany), S.-E. Gryning (Riso, Denmark), S. Joffre (FMI, Finland), A. Rasmussen (DMI, Denmark), P. Tercier (SMA, Switzerland)

As a part of the COST Action 710 (Harmonization of meteorological preprocessors for dispersion modelling), different practical methods for the determination of mixing heights have been compared on the basis of data sets from operational sites (Cabauw/NL, Payerne/CH) and field campaigns (SANA/SADE, D). The comparison includes evaluations of measurements by radiosondes (parcel and Richardson number methods) and sodars as well as modules of operational preprocessors (OML, HPDM, RODOS, FMI, Servizi Territori), based on surface layer scaling for the stable and near-neutral ABL and on the integration of slab models for the convective boundary layer (CBL). All the preprocessors had certain difficulties; if suitable measurements are available, the mixing height should be determined with a parcel method under unstable and a Ri number method under stable conditions, but there are still unsolved questions. Further findings concerning the application and future development of empirical methods and preprocessors will be presented.

Sodar and surface Layer measurements along the The reeves glacier air flow path in antarctica

A. Viola, G. Mastrantonio, T. Georgiadis, M. Tagliazucca , S. Argentini
Istituto di Fisica dell' Atmosfera - CNR
Laboratori di Frascati v. G.Galilei c.p.27 I- 00044 Frascati (Rm)
Tel: 39 6 94186258 Fax: 39 06 94186266 Email: viola@hp.ifsi.fra.cnr.it

Abstract
Two measurements station have been set up in the area of Terranova Bay in summer 1994-95 to study the evolution of the boundary layer during the transition between the winter and the summer circulation. They have been located on the Reeves Neveé (at 1200 m ASL) and on the Nansen Ice Sheet at the confluence of the Reeves Glacier. Both sites were equipped with a triaxial Doppler sodar, and with fast response meteorological sensors. An attempt to relate the depht of the gravity current estimated from sodar data at the Reeves glacier with the katabatic flow observed in both sites is presented. The intercomparison between sonic anemometers and sodars data is presented to determine the reliability of different sensors to describe and interpret the atmospheric circulation with particular attention to the katabatic flow events. The momentum fluxes obtained from the sodar data have been compared with those measured with sonic anemometers

ST19/OA11 Open session on mesoscale studies

01 Mesoscale meteorology

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TRANSPORT PROCESSES OF ATMOSPHERIC POLLUTION IN THE MADRID AIRSHED

B. Artiñano, M. Pujadas, J. Plaza, S. Nuñez, B. Aceña, J. Terés, and H Cabal (Instituto de Medio Ambiente- CIEMAT, Avda. Complutense 22, 28040 Madrid, Spain)

The atmospheric dynamics in the Madrid airshed is governed by thermally induced processes which favours the development of circulations with a marked daily cycle. Four years of intensive experimental campaigns have contributed to characterize the orographic flows, the boundary layer structure, and the mesoscale processes that take place in this part of the Iberian Peninsula. Secondary pollutants have been used as tracers of the airmass transport revealing the magnitude of the space scales involved. These can exceed 100 Km, the distance from the source where the urban plume was detected, and more than 3000 m in height, which is the typical mixing layer depth under strong convection conditions. The role of the topography which delimits the airshed, and specially of the mountain range, has been specially addressed. Mobile units instrumented with ground-based remote sensing sensors, and airborne platforms, have been confirmed as invaluable tools to complement the standard meteorological measurements and air pollution networks, as well as to evaluate modelling results in these type of studies.

MID-LATITUDE CYCLOGENESIS MECHANISMS : A CLIMATOLOGY FROM ECMWF ANALYSES

F. Ayrault and A. Joly (Centre National de Recherches Météorologiques 42,avenue Coriolis 31057 Toulouse France)

Cyclogenesis theoretical models need to be compared with climatological prototypes derived from many cases. To define these prototype cyclones in a relatively objective way, a tracking algorithm is applied to the vorticity maxima encountered in North Atlantic 6-hourly ECMWF analyses. Then a partition of the tracked cyclones is performed. This automatic classification is based on the vertical and horizontal morphology of the events, but also on the time evolution of this morphology. Composite pictures are constructed, mixing the numerous neighbouring cases belonging to the same class. Theoretical models are meaningfully tested against these objective pictures of the reality. With the help of some diagnoses, two important results (among others) are derived from the composite pictures. First, the mechanism of growth is shown to be independent to the mechanism involved in the first appearance of the vorticity maximum. And energetically, baroclinic conversions and kinetic energy dispersion seem to dominate the growth stage.

IDEALIZED NUMERICAL SIMULATIONS OF AIRFLOW IMPINGING ON AN ALPINE-LIKE MOUNTAIN-RANGE

M.H. Bauer (Department of Meteorology, Innrain 52, A-6020 Innsbruck, Austria)
G.J. Mayr und H. Pichler (Department of Meteorology, Innrain 52, A-6020 Innsbruck, Austria)

Meso-scale mountain-barriers like the Alps drastically influence the atmospheric motion. By means of idealized numerical simulations (hydrostatic, adiabatic, inviscid; windspeed, winddirection and static stability constant with height) the flow impinging on an idealized Alpine-shaped mountain (consisting of 27 superposed Gaussian hills) is examined for various angles of the incoming flow to the mountain-range orientation. Situations with and without consideration of the Coriolis effect will be compared. The flow pattern can be explained as a superposition of results for barriers stretched streamwise (aspect ratio $\beta>1$) and spanwise ($\beta<1$) to the initial flow direction. Meridional winds are characterized by strong vertical isentropic displacements connected with foehnic clearing. The highest speeds for winds from S or SW occur north of the Swiss Central Alps, while winds from N or NW produce a maximum south of the Austrian/Italian border. A change of the wind direction resulting in a zonal flow (W or E) leads to a reduction of β and of the Rossbynumber Ro=U/fL (U..windspeed, f...Coriolis parameter, L...moutain length). Therefore the spectrum of the induced waves shifts from vertical and horizontal to mostly horizontal propagation. For a wind impinging from the west the Coriolis force causes an anticyclone with strong winds in the northern Alpine foreland.

MODELLING OF TYPHOON PROPAGATION IN ATMOSPHERE ON THE BASIS OF NONLINEAR SHALLOW WATER EQUATIONS

V.V.Bulatov, Y.V.Vladimirov, S.Y.Dobrokhotov, V.G.Danilov (*Institute for Problems in Mechanics Russian Academy of Sciences, Pr.Vernadskogo 101, 117526 Moscow, Russia)*

The role of singularities for solutions of equations of gas- and hydrodynamics is well known both in the theory of the corresponding equations and in applications. V.P.Maslov established the hypothesis stating that such solutions can describe typhoon and other natural phenomena. A system of two-dimensional nonlinear equations of hydrodynamics ("shallow water"), describing the atmosphere of the Earth in the geostrophic approximation with account of the Earth's rotation is considered. The center of the weak singularity calculated by using the asymptotic representation for a solution of the initial nonlinear system can model the typhoon motion trajectory in the atmosphere of the rotating Earth. By comparising the numerical analysis of weak singularity trajectory with the trajectory motion of the real typhoon "FORREST"(21.09.1983 - 30.09.1983), we observe their quite good qualitative coincidence. This results make it possible to established the following hypothesis. Let us assume that there exists a system of equation that model the typhoon dynamics and let its solutions correspond to a real typhoon. If we know the real typhoon trajectory on a some initial time interval and choose the initial conditions for the corresponding differential equations in such a way that the real and calculated trajectories are close on this initial time interval, then we can suppose that the calculated typhoon trajectory also is close to the real one on the next time interval. This research was supported by the Russian Foundation for Basic Researchers under Grant No.96-01-00937.

MESOSCALE CYCLONES IN THE FRAM STRAIT

B. Brümmer and H. Hoeber (Meteorologisches Institut, Universität Hamburg, Bundesstrasse 55, 20146 Hamburg)

The Fram Strait between Greenland and Spitsbergen is the bottle neck through which the sea ice produced in the Arctic Ocean is exported southward into the Atlantic Ocean. During the field experiment ARKTIS in March 1993 a mesoscale cyclone was observed which developed at the ice edge of the Fram Strait and moved northward over the pack ice. The detection and observation of the cyclone was possible by an array of buoys deployed on the ice and by radiosonde measurements on board RV POLARSTERN. The cyclone was a rather shallow but intense phenomenon; it extended to only 2 km height but was accompanied with low-level wind speeds of up to 20 m/s. The passage of the cyclone had a strong impact on the drift of the sea ice. A similar cyclone event in the same area was reported from the US field experiment CEAREX. It is hypothesized that mesoscale cyclones in the Fram Strait occur more frequently than detected by routine weather analyses and that - by breaking open the pack ice - they play an important role in the regulation of the sea-ice export from the Arctic to the Atlantic Ocean.

MESOSCALE STRUCTURE OF THE FRONTAL SYSTEMS IN THE MEDITERRANEAN SEA FROM THE ERS-1 SCATTEROMETER DATA.

C. Cappa (Istituto di Cosmogeofisica, Consiglio Nazionale delle Ricerche, Corso Fiume, 4, 10133 Torino, Italy)
S. Zecchetto (Istituto per lo Studio della Dinamica delle Grandi Masse, Consiglio Nazionale delle Ricerche, 1364 S. Polo, 30125 Venezia, Italy)

We present the most interesting cases of frontal systems detected by the ERS-1 scatterometer in the Mediterranean Sea. The data analysed span the period from January 1992 to April 1996. The mesoscale structure of the frontal systems has been studied through the wind field and the structure of the Ekman pumping field, i.e. the vertical velocity of the atmospheric Ekman layer. It has been possible to quantify the frontal activity associated to both the cold and warm fronts, and to detect cases of frontogenesis. In analogy with the spatial pattern of the precipitation, the large and the small mesoscale structures (LMSA and SMSA respectively) have been identified. The selected frontal system cases have been associated to the infrared and visible images provided by the Meteosat and to the cloud coverage provided by the ATSR radiometer of ERS-1. The description of the frontal systems provided by the scatterometer has been compared to that derived from the analysis wind fields of the European centre For Medium Range Weather Forecasting (ECMRWF) of Reading, U.K.. This comparison has allowed a better evaluation of the high level of information which it may be derived from the scatterometer wind fields.

FORECAST OF DAILY RAINFALL IN CATCHEMENTS USING MESOSCALE MODEL

P. Diegues, J. Corte Real and C.C. DaCamara (ICAT, Faculty of Sciences, University of Lisbon, 1700 Lisbon, Portugal)

In this study, results relative to the forecast of daily rainfall totals in stations positioned in catchements located in continental Portugal are presented. Forecasts of daily rainfall totals are attempted by using a mesoscale model operating in the Euro-Atlantic sector with initial and boundary conditions provided by a GCM, specifically the RAMS model. Several experiments with RAMS, in an appropriate configuration to continental Portugal, were performed during the winter months of 1989, when days with significant precipitation were observed. It is shown that RAMS model is capable of simulating adequately fields of surface pressure and temperature; however it tends to overestimate relative humidity and wind speed; in general the overall results can be considered reasonable. Regarding precipitation, there is a clear tendency for the dynamic model to forecast correctly the rainfall pattern although rainfall amounts may display, depending on atmospheric conditions, deviations either in point or areal values. Discussion of results and techniques for improvement are offered.

ON THE INTERACTIONS BETWEEN TURBULENCE AND MOISTURE PROCESSES AT COLD FRONTS

C.M. Ewenz (Meteorologisches Institut der Uni Bonn, Auf dem Hügel 20, 53121 Bonn, Germany)
A. Becker (Lehrstuhl für Umweltmeteorologie der Brandenburgischen Technischen Uni Cottbus, Haus 215, Postfach 101344, 03013 Cottbus, Germany)

Diabatic processes caused by moisture, turbulence or energy exchange with the soil surface bear a significant influence on the shape and development of tropospheric fronts and their weather determining ageostrophic cross frontal circulation. The processes are responsible for the large variety observed at atmospheric fronts. A two dimensional meso-scale model developed for numerical simulations of cold fronts over orography and extended by parameterizations for the warm rain processes and the subscale fluxes is applied to study the nonlinearity of these diabatic processes. Four simulations, starting with the same initial potential temperature and along-front jet fields are carried out. The single effects of moisture (run 2) and turbulence (run 3) show significant differences in the ageostrophic cross frontal circulations compared to the dry adiabatic control run (run 1). In run 2 the updraughts are considerably larger due to latent heat release. Clouds develop in the updraughts of the ageostrophic cross frontal circulation. The turbulence parametrization leads to a strong modification of the jet and an enhanced cross frontal wind in the planetary boundary layer. At least the synergetic effects of turbulence and moisture including the coupling processes (run 4) show the superposition of the single effects as well as the nonlinear additional effect of turbulent moisture transports.

OROGRAPHIC EFFECTS OVER THE ANDES MOUNTAINS PREDICTED USING THE NCEP/UB REGIONAL ETA MODEL

S. C. Chou (Instituto Nacional de Pesquisas Espaciais, CPTEC/INPE, 12630-000, SP, Brazil)

The Andes Mountains exhibit very narrow east-west extension, but stand over 4000 m in many parts along its north-south extension, causing a strong barrier effect to the westerlies. The subtropical upper level jet crosses the mountains and moves over Northern Argentina at about 30°S. This situation generally occurs when the cold fronts move northeastward. Part of the front crosses the mountains at the southern end where the altitudes are lower. The air descends sharply on the lee side of the mountains causing warming, drying and strong winds, and rises to the original height near South of Brazil. These winds are locally known as Zonda winds. During summer, in the absence of such strong jet crossing the top of the mountains, the air moves smoothly in the horizontal. Both cenarios were forecasted using the NCEP/UB Regional Eta model. This model is running operationally over South America with 40 km horizontal resolution and 38 layers in the vertical. Due to the characteristics of the step-mountain or eta coordinate; the errors in the calculation of horizontal derivatives are reduced, improving the forecasts near the mountain regions. During the cases of strong jets over the mountains the isentropic surfaces can dive from the top of the mountain at about 600 mb to 850 mb in a hydraulic jump resemblance. The phenomenon lasts less than a day, and causes large temperature variation in a day to the villages at the foot of the hills. Stability and turbulence parameters are shown for both cases using model outputs.

ANALYSIS OF OZONE EPISODES AND THEIR INHERENT STRUCTURE IN SEVERAL LANDSCAPES AT THE SOUTHERN BALTIC COAST

Sabine Eckert & Otto Stüdemann (Universität Rostock, Fachbereich Landeskultur und Umweltschutz, AG Angewandte Meteorologie und Klimatologie, J.-v.-Liebig-Weg 6, D-18051 Rostock)

In previous investigations it was shown that macro-, meso and microscale processes of atmosperic dynamic, natural stock with an anthropogenic and biogenic ozone forming capacity and the mesoscale variability of climatic elements cause a marked differentiation of near ground ozone concentrations within ozone episodes at the southern Baltic coast.
The investigation area with an extent of 80x10 km² is represented by an urban, a suburban and two clean air measurement sites.
In the period from June to August 1995 4 ozone episodes were evident with modifications at every site. Distinct features were the length of daily periods where the critical ozone level 80µg/m³ is exceeded, the daily beginning of this exceedings and the frequence of exceedings during the air-mass climatically determined ozone episodes. Unlike the recommendations of the UN-ECE workshop report on critical ozone levels (1993) we included exceedings of critical levels from 7 am to 9 pm. Measurements at the catena Zingst - Rostock-Holbeinplatz - Rostock-Stuthof - Gülzow showed that 5-20 % of the exceedings started before 8 am. Between 7 am and 9 pm the mean values of ozone concentrations at the clean air sites were above the critical level. The parameters of the stochastic dataset are tested for significance. Significant differentiations of ozone episodes at the 4 measurement sites prove that an adequate network density has to be calculated for an objective assessment of the regional heterogeinity of ozone concentrations in many applications e.g. regional planning, recreation.

MESOSCALE CIRCULATION OVER CALABRIA AND THEIR DEPENDENCE ON SYNOPTIC SCALE FLOW

S. Federico, L. Casella, C. Bellecci
Dipartimento di Fisica-Università degli studi della Calabria
87036 Arcavacata di Rende (CS), Italy

In this study we apply a 3D mesoscale model to investigate the charateristic flows over Calabria and theirs interaction with environment.
Special region orography suggests that the mesoscale circulations are controlled by sea-breeze circulation and upslope flow. This particular geography determines also very strong convective activities (sunderstorms) even in winter when the radiative forcing is at its minimum. These strong convective activities can be perturbed by particular integration conditions and effects in same sites are reported.
We show the general aspects of the model and we discuss the impact of synoptic scale flow on the TFMC (Thermally Forced Mesoscale Flow)

EDDY CORRELATION MEASUREMENTS ON TWO SITES OF SPRUCE POPULATIONS IN THE VOSGES MOUNTAINS (F) AS WELL AS ON ONE SITE IN THE ERZ MOUNTAINS (G)

U. Feistel, P. Biron und G. Najjar (Centre d'Etudes et de Recherches Eco-Géographiques, 3 rue de l'Argonne, 67083 Strasbourg Cedex, France)
Ch. Bernhofer, Th. Grünwald (Technische Universität Dresden, Institut für Hydrologie und Meteorologie, Pienner Str. 9, 01737 Tharandt, Germany)

Since 1994, eddy correlation measurements based on the eddy correlation/ energy balance method (ECEB) have been carried out within the framework of the REKLIP programme in order to determine the latent heat streams. The measurements have taken place on two 30-year old population sites in the Strengbach (F) catchment area (1000 m a.s.l.). The two sites differ only in population density and in slope orientation and gradient. The resulting variations in real evapotranspiration make it therefore possible to quantify the respective factors influencing evapotranspiration. The simultaneous determination of soil humidity (neutron probe and tensiometer) makes it possible to set up specific reduction functions especially in periods of drouth. The results provide the basis for improved modelling of water and energy balances of forested catchment areas.
Similar measurements have been carried out on a spruce population site at 700 m a.s.l. of the Erz mountains (G). Besides process analysis, these measurements allow for conclusions relating to regionalisation.

KINEMATIC AND THERMODYNAMIC VARIABILITY OF THE ATMOSPHERE OVER NE BRAZIL

M.G. Filippova (Moscow State University, B-234, Leninskie Gory, Moscow, 117234, RUSSIA)
G.V. Mostovoi (Hydrometeorological Centre of Russia, Bol'shoi Predtechensky per., 9-13, Moscow, 123242, RUSSIA)
Vicente de P. Silva Filho (Foundation for Meteorology and Hydrology - FUNCEME, Bezerra de Menezes 1900, Fortaleza CE 60325-002, BRAZIL)

Based on aerological observations of EMAS Experiment (March-April 1995) the diagnostic calculations for the budget components of vorticity, sensible heat and moisture are performed for three stations in the NE Brazil with an average separation of about 300 km. Being only 5° southward from the equator, the region above is characterized climatically as an arid zone with a great year- to-year rainfall variation. The estimations of vertical profiles for adiabatic heating/cooling and for the sources/sinks of vorticity related with mesoscale convective processes are made to study the precipitation mechanism, which is mainly due to short-lived (< 12 hours) and extremly space-concentrated convective disturbances,. The calculations provide a useful means to clarify typical kinematic and thermodynamic structure of the equatorial atmosphere over NE Brazil during rainfall season in terms of vertical velocity, vorticity, horizontal divergence, potential and equivalent-potential air temperature.

THE 'LITFASS' PROJECT OF THE GERMAN WEATHER SERVICE

Th. Foken, J. Neisser, S. H. Richter, W. Rosenow (German Weather Service, Meteorological Observatory, D-15864 Lindenberg, FRG),
E. Heise, E. Müller (German Weather Service, Meteorological Research and Development, P. O. Box 100465, D-63004 Offenbach, FRG),
H. Herzog (German Weather Service, Meteorological Observatory, P. O. Box 600552, D-14405 Potsdam, FRG)

LITFASS is an acronym for 'Lindenberg Inhomogeneous Terrain - Fluxes between Atmosphere and Surface: a Long-term Study'. The scientific objective of LITFASS is to determine and to model/parametrize the fluxes of momentum, heat, water and other substances, representative for the horizontal scale of the order of 10 km (grid length of the present operational numerical weather prediction (NWP) model DM of the German Weather Service) over heterogeneous land surfaces. A general approach will be to take into account sub-grid scale heterogeneity in the characteristics of the land surface, in the forcing conditions and the resulting fluxes. The LITFASS project is divided into three different sub-projects: Development of an non-hydrostatic model with a grid-size of 100 m, experimental investigations within an 20 km x 20 km area around the Lindenberg Observatory, and data management. The duration of the project is planned from 1995 up to 2000. There is a wide interest for cooperation with research institutes in Germany and in other countries. In this context it is planned to execute an experiment of the BALTEX-Project 1998 in the Lindenberg area using the facilities of LITFASS.

MESOSCALE MODELING OF THE WIND CLIMATE OF IRELAND

H. P. Frank (Risø National Laboratory, Meteorology and Wind Energy Department, DK-4000 Roskilde, Denmark)

The wind climate of Ireland has been calculated using the Karlsruhe Atmospheric Mesoscale Model KAMM. The climatology is represented by 65 frequency classes of geostrophic wind. They are chosen as equidistant direction sectors and speed classes of equal frequency in a sector. They were carefully selected in order to reproduce the original power of the geostrophic wind distribution. The results are compared with data from the European Wind Atlas (Troen and Petersen, 1989) and newer data for Ireland which has been analyzed using the Wind Atlas Analysis and Application Program WAsP.
The comparison with wind atlas data is fair. The simulations overestimate the wind power at stations with low winds because no daily cycle and thermal forcing was included. Stations with higher wind power than average are better reproduced.
Different frequencies can be asigned to the classes of geostrophic wind using e.g. different years of observations or observed winds from radiosondes and analyzed winds from NWP models as input. Also, this allows to investigate the effects of non-uniform geostrophic wind. Close to mountain ranges the prediceted power is more sensitive to the frequency distribution of geostrophic winds than in flat areas which can be expected.

OROGRAPHIC CLOUDS FORMING IN THE NORTHERN MASSIF CENTRAL

G. Gérémy, A. Flossmann and W. Wobrock (Laboratoire de Météorologie Physique, CNRS/OPGC, Université B. Pascal, 24 avenue des Landais, 63177 Aubière, France)

The Chaîne des Puys is a mountainous barrier in the northern Massif Central (France). The Puy de Dôme, highest point of this barrier (1465m), is place for the European Cloud Ice Moutain Experiment (CIME) in winter 1997. For this reason a great number of measurements on atmospheric chemistry, cloud microphysics as well as meteorology will be performed on the summit of the Puy de Dôme. To understand the formation and evolution of orographic clouds forming on the Puy de Dôme, simulations of the flow developing in the northern Massif Central are made. We use the 3D, mesoscale, non hydrostatic Clark Model which has the feature of terrain following vertical coordinate and allows several nested domains to zoom into the area of interest. 3 nested domains are defined: the first (grid=1.8km; dim.=205x158km) includes the north part of the Massif Central in order to well describe the meso-scale environment, the second (grid=600m; dim.=80x80km) allows to study the orographic waves, and the third (grid=200m; dim.=25x20km) zooms in the experimental area and thus allows us to study the local phenomena like orographic clouds and high winds in the lee of the mountains. The results for the wind field are compared with routine wind profiles measurements by a radar ST in the lee of the mountain. The simulated results are furthermore used to initialize the microphysical model DESCAM (DEtailed SCAvenging and Microphysics). The microphysical properties of the evolving clouds are compared with first results from the cloud campaign of CIME.

2D-AIRFLOW OVER TWIN PEAKS

A. Gohm, G.J. Mayr, and H. Pichler (Department of Meteorology and Geophysics, Innrain 52, A-6020 Innsbruck, Austria)

Various investigations about the influence of single bell-shaped ridges on the atmospheric flow have been done in the past. For gaining insights into the effect of complex orography on the generation of internal gravity waves, the present work investigates two dimensional flow over a double-mountain profil. As a simplification of the real atmosphere, the initial velocity U and bouyancy frequency N of the inflow are kept constant with height. Numerical results are first compared with existing linear theory for small mountain heights. The simulations are then extended to nonlinear cases with wave-breaking and upstream blocking. Drag varies as function of the distance between the two peaks and the nondimensional mountain height. Wave-breaking above the downslope of *both* mountains occurs only for a critical minimum peak separation. When cold air is blocked on the windward side of the second mountain the maximum of vertical velocity lies just above the upstream edge of the blocked layer. Passing the second peak the flow moves down along the leeslope where strong surface winds are generated.

CLIMATOLOGICAL WIND ATLAS OF THE DARSS-ZINGST-RÜGEN BODDEN-CHAIN IN THE SOUTH-BALTIC SEA

D. Hinneburg and B.-R. Beckmann (Institut für Meteorologie, Universität Leipzig, Stephanstr. 3, D-04103 Leipzig, Germany)

The climatological wind atlas presents a complete set of simulated regional wind situations, the climatological frequency and mean duration of each situation as well as the mean wind distributions for the various wind directions. The region considered extends over 90 km x 70 km and is situated between Rostock and Bergen/Rügen. The horizontal grid distance amounts to 1 km.
The climatological investigations are based on the long-time series of the wind data at a coastal station. In order to get generalized informations, the data were homogenized and normalized for the local topography. The frequency distribution gives the relative values for each of the simulated wind situations, which belong to fixed geostrophic wind speeds and directions. The geostrophic wind directions are 0, 30, ..., 330°, the speeds are 5, 10, 15, ..., 40 ms^{-1}. The mean duration of persistence is also determined for each class.
For the simulations the non-hydrostatic mesoscale atmospheric model GESIMA in a modified version was applied. Special effort of modification was directed to the inclusion of sea-state and sub-scale roughness-structures as well as to a proper vertical grid resolution. The very shallow numerical grid space of 4 m in the lowest numerical layers enables the internal boundary layers to establish gradually. The thermal atmospheric stratification is supposed to be stable above the mixing layer with mean gradient for all wind directions.

THE MESOSCALE SIMULATIONS FOR THE WIND ATLAS OF THE SOUTH-BALTIC BODDEN LANDSCAPE

D. Hinneburg, A. Raabe, and G. Tetzlaff (Institut für Meteorologie, Universität Leipzig, Stephanstr. 3, D-04103 Leipzig, Germany)

A complete set of stationary states of the atmospheric flow over terrain with complex structures of high roughness-jumps is calculated. The area of the simulations amounts to 90 km x 70 km with a step size of 1 km. The non-hydrostatic mesoscale model GESIMA is applied in a modified version. The modifications enable the model to include subscale roughness-structures, the sea-state in dependence on wind fetch and water depth, to properly account for the inhomogeneous vertical grid spacing, and to adiabatically adapt to the differences in the surface roughness. Moreover, the changes improve the reliability and precision of the calculations. The main modifications in detail are as follows:
1) Determination of an effective scalic roughness-length by area-averaging the subscale surface fluxes based on a blending height.
2) Replacement of the Charnock formula for the roughness of the water surface by a hybrid model depending on the wave height and the ratio between the wave speed and the friction velocity. Both wave heigth and wave speed are affected by the wind speed, wind fetch and water depth.
3) Adiabatical initialization of the local roughness differences.
4) Framing of the region under consideration by addition of two grid points on each side of the horizontal grid.
5) Insertion of a second vertical grid for the quantities describing turbulence.

PV ADVECTION AND THE OMEGA EQUATION

B.J.Hoskins and
D.W.Jones (University of Reading, Dept. of Meteorology, Reading)

PV thinking and the omega equation plus vorticity equation provide two distinct perspectives on the development of mid-latitude weather systems. A third perspective is provided by isentropic relative flow. In this study the three perspectives are united through consideration of the form of the omega equation in which the vertical velocity is split into three parts. The first part is the isentropic upglide. If the system of interest is steady in the coordinate frame used then this describes all the vertical motion. The second part is the vertical motion associated with the differential advection of PV, and the third part is associated with the boundary temperature advection. The analysis will be applied to the Eady model and to isolated PV features to illustrate the relative importance of the various terms and links between the three perspectives of mid-latitude development. The analysis in the presence of diabatic processes will also be discussed.

APPLICATION OF NEW VERTICAL MOTION DIAGNOSTICS

D.W.Jones and
B.J.Hoskins(University of Reading, Dept. of Meteorology, Reading)

The theoretical framework in which vertical motion is divided into three components, associated with isentropic upglide, differential PV advection and boundary thermal advection is applied to synoptic features in a baroclinic wave life-cycle and an analysis of an observed mid-latitude cyclone. Viewed in the frame of reference moving with the system , the small amplitude baroclinic wave is dominated by the isentropic upglide, reduced by the boundary thermal advection term. The PV advection term has a weak maximum at the steering level and the tropapause. However in the large amplitude, occluding system the PV advection term becomes much more important. Comparison will be made with the relative importance of the three components in the developing and maturing real system.

A GENERAL THEORY FOR OPTIMAL MODE DISTURBANCES IN TWO WAVE SYSTEMS OF BAROCLINIC AND BAROTROPIC INSTABILITY

M.N. Juckes (Meteorologisches Institut der Universität München)

A range of atmospheric instabilities can be described in terms of the interaction between two counter-propagating waves. The simplest example is Rayleigh shear instability, in which the two waves propagate on opposing gradients of vorticity in a barotropic fluid. Another example is given by Eady's model of baroclinic instability, in which the two waves are supported by horizontally uniform temperature gradients on the ground and tropopause. More recently, the author has derived two further analytic solutions. Firstly, for interacting waves on opposing temperature gradients on a single horizontal surface, which can be taken as the ground or the tropopause and, secondly, for waves on the ground and tropopause supported by temperature gradients concentrated into narrow frontal zones. The normal mode approach is applicable when a disturbance has sufficient time to evolve into a fixed spatial pattern. In practice, when the initial amplitude of the disturbance is in the range relevant to atmospheric motions, the disturbance becomes non-linear before this fixed pattern is attained. The amplification of an evolving spatial pattern can be described using the theory of optimal modes. The need to assign a well defined amplitude to an evolving structure introduces a degree of arbitrariness into the theory. Nevertheless, the two-wave problems listed above have a sufficiently simple structure to permit a general solution.

THE STRUCTURE OF BAROCLINIC WAVES GROWING ON FRONTAL TEMPERATURE GRADIENTS

M.N. Juckes (Meteorologisches Institut der Universität München)

An analytic, semi-geostrophic, solution for baroclinic waves growing in uniform potential vorticity flow with boundary temperature gradients concentrated in fronts is discussed. The solution has some degree of generality, in that it can be applied to arbitrary frontal surface temperature distributions provided the boundary temperature gradient decreases with distance from the front faster than an inverse cube law. It can be shown that the scaling assumptions which lead to semi-geostrophic theory remain uniformly valid as frontal collapse is approached, even though the along front component of the wind becomes large. This confirms the conclusions of numerical studies by other authors.

CONVECTIVELY GENERATED GRAVITY WAVES FOUND IN RADIOSONDE DATA

T. Kerzenmacher and S. D. Mobbs (The Environment Centre, University of Leeds, Leeds LS2 9JT, UK)

Gravity waves in the atmosphere can be generated by deep convection as well as by orography. A study has been carried out using radiosonde data to detect the simultaneous occurrence of deep convection in the troposphere and internal waves or inertial waves in the stratosphere. Several months of data from the UK station Camborne (50.2^{0}N, 5.3^{0}W) were used. Convective available potential energy (CAPE) for air parcels lifted from the 850 hPa level was used as an indicator of the likely occurrence of deep convection. Internal gravity waves (short horizontal wavelengths) were detected through their effect on the ascent rate of sondes (typical vertical velocity perturbations are 1 ms^{-1}). Inertial waves or inertio-gravity waves (long horizontal wavelengths) were detected by examining the hodograph (u-v diagram); the waves appear as loops in the hodograph. Cases of correspondence between high values of CAPE and the existence of waves in the stratosphere will be described.

MESOSCALE AND MICROPHYSICAL NUMERICAL SIMULATION IN WINTER FRONT RAINBANDS

Svetlana V. Krakovskaia (Ukrainian Hydrometeorological Research Institute, 37 Nauki Av., Kiev-252650, Ukraine; e-mail: krasvet@uasoiro.freenet.kiev.ua)

To study winter frontal cloudiness and precipitation a special algorithm for combined using 3-D mesoscale and 1-D microphysical numerical models was developed The 3 D model is a diagnostic LAM with stretched grid. The resolution in the simulation was varied from 12.5 km near a target area, when rainband passed over it, up to 100 km at the edges of the studied system. The model domain is 1200 x 800 km The model interpolates data of radiosounds in chosen grid points, gives common description of frontal rainbands' mesostructure and prepares 3-D fields of main meteorological parameters for the microphysical model. The 1-D microphysical model includes detailed descriptions of evolution processes of cloud particles (droplets, raindrops, ice crystals, nuclei, etc.). These processes are generation of cloud particles on CCN and IN, freezing, collection of raindrops and ice crystals for droplets, etc. The 1-D model takes input data from the grid points of the 3-D simulation accounting front's displacing. Thus this combined simulation is more

AIRBORNE SEA BREEZE AND COLD FRONT STUDIES IN SOUTH AUSTRALIA

M. Kremer and C.M. Ewenz (Meteorologisches Institut der Uni Bonn, Auf dem Hügel 20, 53121 Bonn, Germany)

Several airborne sea breeze (sb) and cold front (cf) measurements between 1988 and 1994 in cooperation with the Flinders Institut for Atmospheric and Marine Sciences (FIAMS) in South Australia were focused on the sensible and latent heat budgets in the vicinity of the front and on the frontogenesis/frontolysis processes. The first missions with a well–instrumented motorglider (Grob G109B), limited on the smaller scale sea breezes, yielded data sets of the frontal structure in the cross frontal direction. The results showed the effects of confluence-generated updraughts, the shear instability causing bulges and clefts in the frontal surface as well as the produced frontal head and the processes related to differential heating and moistening. The following flights with a two-engine aircraft (Cessna 340II) in some cases together with the motorglider gave a larger range of possible measurements. The sb-flights were focused on the improvement of the results and the solution of uncovered problems, like full sea breeze circulations, baby sea breezes, and three dimensional sb-analysis. The cold front research flights with the two engine aircraft shed more light on the shallow cool changes, often observed in Australia. The results show the differences between wide transition zones with a small temperature gradient, but existing over several tens of kilometres and narrow zones with large gradients and strong cross frontal circulations, often connected with severe weather activities.

NUMERICAL SIMULATIONS OF THERMALLY INDUCED CIRCULATIONS FOR THE AREA OF THE GERMAN BIGHT FOR SPRING 1995

Lenz, C.-J.; Schlünzen, K. H.; Schatzmann, M. (Meteorologisches Institut, Universität Hamburg, Bundesstr. 55, D–20146 Hamburg);
Majewski, D. (Deutscher Wetterdienst, Abteilung Forschung und Entwicklung, Kaiserleistr. 42, D–63067 Offenbach am Main)

Data from routine weather prediction models are available in a horizontal resolution of more than 10 kilometers. In general, these data do not include mesoscale–γ atmospheric phenomena, caused, for example, by temperature differences between the land and sea surfaces or by tidal influences. However, these mentioned coastal atmospheric phenomena can be incorporated in the data by calculating them with high–resolution atmospheric models.

The results of the Deutschland–model, the high–resolution routine prediction model of the German Weather Service, are used to initialize and to drive the non–hydrostatic mesoscale transport and fluid model METRAS through a one–way nesting method. In this contribution results of both models, METRAS and the driving Deutschland–model, are presented concerning the wind, temperature and humidity fields as well as the surface fluxes of momentum, heat and moisture. The model simulations were performed for the area of the German Bight and the adjacent coastal regions for the measuring period of the KUSTOS–experiment (Coastal Mass and Energy Fluxes — The Land–Sea Transition in the Southeastern North Sea), which took place in spring 1995.

THE STATISTICAL MIXTURE DISTRIBUTION USED TO APPROXIMATE A WINDROSE OF A DEFINED WIND TYPE

Inga Lisac, Ph.D., Assistant Professor
Bogdan Zelenko, Ph.D., Associate Professor
Živko Trošić, M. Sc., Scientific Assistant

Warm, humid and strong wind in the Adriatic sea and coastal area, blowing mostly from southeast quadrant is known under name *jugo*, customarily considered as sirocco. This wind type can be extracted from the entire wind data, by the criteria considering wind direction and velocity intervals, as well as continuous duration above a defined time threshold. Applying so defined criteria the empirical wind rose related to jugo events for a site can be obtained. Such wind roses for three coastal stations were approximated by statistical mixture distribution and described by corresponding parameters. This enables quantitative, objective and simpler comparison of results obtained for several samples.

ENERGY BUDGETS OF DRY AND MOIST STATIC ENERGIES OVER THE EURO ATLANTIC REGION FROM A MESOSCALE MODEL

Lourdes Bugalho (Meteorological Institute, 1700 Lisbon, Portugal)
J. Corte Real and P. Diegues (Department of Physics, University of Lisbon, 1700 Lisbon, Portugal)

In this study an attempt is made to identify areas of convective activity, where rainfall can be abundant, using energetic parameters derived from a mesoscale model. The HIRHAM model merges physical parametrizations from ECHAM model with the dynamics of HIRLAM. In this study energy budgets of dry and moist static energies are evaluated using HIRHAM model operating over an area covering North Atlantic, Western Europe and North Africa, driven by the four daily ECMWF analysis (00, 06, 12 and 18 UTC) Precipitation areas are identified from the apparent heat and moisture sources as obtained from model's output. Results are compared with observed distribution of clouds as revealed by satellite imagery, leading to the conclusion that regions of important convective activity, in general associated with frontal systems or isolated depressions as well as with centers of maximum precipitation, are highly spatially correlated with the apparent heat and moist sources.

DOWNSLOPE WINDSTORM-ENHANCEMENT THROUGH MOISTURE?

G.J. Mayr, Department of Meteorology and Geophysics, Innrain 52, A-6020 Innsbruck, Austria, e-mail: Georg.Mayr@uibk.ac.at

When part of the atmosphere becomes saturated, its effective stability and thus the buoyancy-restoring force decrease, which in turn should weaken the wave amplitude and downslope windstorms associated with flow over obstacles, as has been shown in several earlier studies.
This paper applies idealized, two-dimensional numerical simulations of flow over a Gauss-shaped obstacle to show that there exists an exemption to the above conclusion: For certain heights of cloud base high drag states occur for mountains considerably lower than the critical height required in the completely dry case. The necessary conditions and the physical mechanisms involved will be explained in the talk.

NUMERICAL MODELLING OF GRAVITY WAVE DRAG IN THE ISLAND OF MADEIRA

Pedro M. A. Miranda (University of Lisbon, Centro de Geofísica, R. Escola Politécnica 58, 1250 Lisboa, Portugal, e-Mail: fmiranda@cc.fc.ul.pt)
J. J. Ferreira (Instituto de Meteorologia, Rua C, Aeroporto de Lisboa, Portugal)

In 1993, a field experiment was conducted in the Island of Madeira to measure pressure differences across the island with a set of high precision barographs. The data obtained, for a three-week period during the month of April, was used to infer pressure differences across the island for different background flow. At the same time, local radiosondes profiles, one every twelve hours, surface observations from a small upstream island, and ECMWF analysis for the full period of observations were collected and analysed. These data was used to perform a large number of numerical experiments, using both a simple linear model and a non-hydrostatic non-linear model. Pressure differences obtained with the two models were compared with observations and a number of sensitivity tests were done, to assess the influence of the different input parameters, including the details of the upstream profile and the effect of the transient response to changes in the boundary conditions.
The results obtained may be of interest to gravity wave drag parametrization and also give interesting information on the impact of very disturbed radiosonde data on large scale model analysis.

CLASSIFICATION OF THE ATMOSPHERIC FRONTS ALOFT. HYDRODYNAMIC MODEL OF THE MATURE FRONT

E. Morozovsky, G.I. Burde, L.N. Gutman and A. Zangvil (J. Blaustein Institute for Desert Research, Ben-Gurion University, Sede-Boker Campus 84990, Israel)

Analytical model of the atmospheric front based on the linearized equations for horizontal motion and hydrostatic equation is built. The model deals with cold and warm air masses of different and constant potential temperatures separated by the interface. The entire system is set in motion by the external large-scale pressure field and is propagating horizontally at a constant velocity without changing the interface shape. In the coordinate system moving with the front the process is considered as a steady-state. Formulation of the problem for the moving front is possible due to incorporating a neutral logarithmic surface layer in the model so that the non-slip condition at the earth's surface is replaced by a matching condition at the upper boundary of the surface layer. The model is applicable to a mature atmospheric front which can be considered as the final stage of frontogenetical processes. The linearization made in the horizontal equations of motion (it is justified in this problem of a mature steady front where the processes in a tranzitionzone between cold and warm air masses are out of consideration) permits analytical closed-form solution which highlights the basic nondimensional parameters of the problem and enables one to classify solutions. Here we concentrate on the classification of possible types of fronts aloft for which the interface does not intersect the upper boundary of the surface layer. A chart of solutions is built and a stability analysis is used to pick out the front aloft types which can be realized in nature.

SIMULATION OF NOCTURNAL DRAINAGE FLOW WITH THE 'LOKAL MODELL'

M.Minotte and J. Steppeler (Deutscher Wetterdienst, Department of Research and Development, Kaiserleistr. 42, Postfach 100465, 63004 Offenbach, Germany)

The new Lokal Modell (LM) being in development at Deutscher Wetterdienst is a nonhydrostatic model which is intended to be used for a broad range of applications. Among those, for the climate applications, it should be possible to simulate nocturnal drainage flows where the horizontal grid size should be less than 500 m. During cloudless and windless nights drainage flows can form over slopes as a result of the cooling of the earth surface. The rate of production of cold air depends on many parameters like the soil type, the vegetation cover, the terrain inclination... The knowledge of the formation and the behaviour of drainage flows would allow a better regional and urban planning by avoiding the frost over cultured areas but also in respect of the cleaning of overheated and polluted residential areas and transporting of air pollutants. In this work a simulation of such a drainage flow is done with the LM for a valley near Kaiserslautern (SW of Germany). The topographical and land use data are given in a grid size of 40 m, the area contains 115 * 90 grid points. The calculation starts at 21 UTC and is done for 6 hours. This experiment points out the capability of the LM to be used for climate applications in 3-D with a very high resolution and the necessity of further studies, particularly of the effects of the boundary conditions and the land use.

A SENSITVITY STUDY ON THE IMPACT OF LANDUSE DATA SETS ON WEATHER PREDICTION

Nicole Mölders, Armin Raabe (LIM - Institut für Meteorologie, Universität Leipzig, Stephanstraße 3, D-04103 Leipzig, Germany), Ulrich Strasser, Karl Schneider, Wolfram Mauser (Institut für Geographie, Universität München, Luisenstraße 37, D-80333 München, Germany)

The impact of landuse data sets on the prediction of the variables of state as well as on the water and energy fluxes was exemplarily investigated by simulations alternatively applying digitized and satellite derived landuse data sets within the framework of a mosaic approach. The fractional coverage of the various landuse types only slightly differs, but the location of occurrence of the landuse shows significant differences within the model domain. Although the distributions of daily averages of temperature and moisture differ less than 0.2 K (1 %) and 0.2 g/kg (1.5 %), respectively, at some location appreciable differences in the daily averages of soil moisture (0.19 m^3m^{-3}, 29 %), soil temperature (2.3 K, 12 %), sensible (30 Wm^{-2}, 29 %) and latent heat fluxes (32 Wm^{-2}, 34 %) occur. During the daytime the area average fluxes of regions dominated by the same landuse in both the data sets differ up to 165 Wm^{-2} (35 %) except for *grassland* for which they are smaller than for all other landuse types. Generally, the greatest differences may occur if a dominance of *grassland* changes to a dominance of *forest* or *settlements* because the surface characteristics differ the strongest for these landuse types. The results suggest that, although on the mesoscale the predicted fluxes significantly differ, on the large scale point of view it only seems of importance that a certain flux occurs within the model domain.

SOLAR ACTIVITY AND TEMPORAL BEHAVIOR OF TEMPERATURE ANOMALIES (GLOBAL AND HEMISPHERIC)

Nataly.M.Astafyeva (Spase Research Institute, Profsoyuznaya, 84/32, 117810 Moscow, Russia)

We study the temporal behavior of Jones's data - the sets of anomalies of the annual average air temperature (global and hemispheric) near the Earth's surface from 1954 to 1990 years. We use Fourier and wavelet transform and correlation technique (for data and for WT coefficients - wavelet spectrum - too). The temporal behavior of global and hemispheric data are qualitatively similar: the scales about 25-30 years separate the small-scale area of the wavelet spectrum (all temporal dynamics are concentrated here) from the large-scale area (the temporal dynamics look like almost linear trend). The main difference between hemispheres - presumabely due to the greater amount of land and stronger anthropogenic factor - being that the warming trend in the Northern hemisphere is slightly stronger and goes first in time. Note that trend (difference between data and the result of opposite WT) have no bend at the begin of our centure. The comparison and mutual correlations with the results of the Wolf numbers analysis offer to investigate in more detail the small timescale area dynamics and connection with Solar activity. There are the correlation with about 11 years cycle (but with the time lag - presumabely due to the inertion of the ocean-atmosphere system) and with about 22 years cycle (the scale slightly larger for Southern hemisphere) and the law level of correlation for the longer timescales.

INITIALISATION OF A NON-HYDROSTATIC MESO-SCALE MODEL WITH DOPPLER RADAR DATA.

M. NURET and M. CHONG (Centre National de Recherches Météorologiques (METEO-FRANCE et CNRS), 42 avenue G.Coriolis, 31057-Toulouse Cedex, France)

TOGA/COARE is a project which has been designed to try to understand the role of the warm pool of the Western Pacific Ocean on the Tropical Ocean circulation and its impact on the global atmospheric circulation. It includes an intensive four-months field program (November 1992 - February 1993), during which many observing facilities were deployed. Among those, airborne Doppler radars were involved in aircraft missions to sample mesoscale convective systems (MCS). The kinematic wind-field (3D) that can be derived from the Doppler-radar data provides an extensive survey of the circulation inside the convective system.

The aim of this paper is to propose an efficient method to use those data in order to define the initial fields for the mesoscale non-hydrostatic (MESO-NH) model of Centre National de Recherches en Meteorologie (CNRM) and Laboratoire d'Aerologie (LA).

The approach is based on the mesoscale optimal interpolation scheme (CANARI-ALADIN) developed at Meteo-France: radar derived winds, discretized on a 10km grid mesh, are combined with larger scale analyzed fields (guess-field) in order to provide the initial state.

During TOGA-COARE a MCS was sampled on 12 December 1992 from 1800 UTC to 2000 UTC, and then re-observed 24 hours later. Analysis incorporating radar-derived wind is performed for the 12 December 1800 UTC. The mesoscale model is then run over a 24 hour period in order to validate non-hydrostatic simulation against Doppler-radar observations or GMS4 IR satellite images (1800 UTC, 13 December).

VALIDATION TESTS OF A NON-HYDROSTATIC MESOSCALE MODEL

Rui Salgado (Universidade de Évora, R. Romão Ramalho, 59, 7000 Évora, Portugal, e-Mail: rsal@ce.uevora.pt)
Pedro M. A. Miranda and M. A. Teixeira (Univ. Lisbon, Centro de Geofísica)

This paper reports on some developments which have been made on the non-hydrostatic NH3D model, initially developed by Miranda and James, at the University of Reading. These developments include the coupling with the ISBA surface model (Noilhan et Planton) and new equations for condensed water and precipitation.
Different validation tests were performed, including several comparisons with published results for flow around idealised mountains with different upstream profiles, in cases where cloud formation or precipitation are expected.
The EFEDA dataset is used to validate the coupling between the atmospheric and the surface model. The problem of initialisation of soil parameters is also addressed with some sensitivity studies, using observational data from a semi-arid region in the South of Portugal.

APPLICATION OF NUMERICAL MODELS FOR RESEARCH OF WINTER FRONTAL CLOUD SYSTEMS

A.M.Pirnach (Ukrainian Hydrometeorological Research Institute, Kiev, Ukraine)

Two- and three-dimension numerical models of two occluded winter frontal systems passed over Ukraine and two-dimensional model of occluded frontal system passed over USA were considered. Two-dimension model with nested and scretched grids was used to simulate of convective cell embeded in stratiform cloudiness for one case. Simulated atmospheric fronts exhibited many features described earlier for other regions in midlatitudes: hyperbaroclinic zones of different mesoscales, small and large mesoscale rainbands, embeded convective cells, wave-like features of cloud and precipitation evolution and etc. The precipitable possibility of clouds was defined by dynamical features chiefly. The microphysical mechanisms had crucial role in cloud and precipitation formation if there is lack of their total activity to realize all presipitable moisture.

NUMERICAL MODELLING OF LAKE AND SEA BREEZES

Pedro Soares, Pedro M. A. Miranda (University of Lisbon, Centro de Geofísica, R. Escola Politécnica 58, 1250 Lisboa, Portugal, e-Mail: fmiranda@cc.fc.ul.pt)
Rui Salgado (Universidade de Évora)

The present study deals with the problem of the evaluation of the local impact of sea breezes, lake breezes and some non-classical mesoscale circulations. The relevance of these effects is well established, but its real magnitude is largely unknown in the case of small and medium size lakes, irregular coastlines or thermal forcing due to heterogeneities in the land use. The study presents results from a number of numerical experiments for both idealized and realistic surface distributions of the sensible heat flux, including the case of a flat land surface with a simple coastline, the effect of orography, the effect of convergence zones in a convex coastline and the interaction between the couple of breeze circulations produced at the two margins of a mesoscale lake. The well known Florida sea breeze case is used as a validation test for the model. An extension of the linear theory of Rotunno, valid for the case of a mesoscale lake is also presented and its results are found to compare well with non-linear numerical results.

ON THE DEVELOPMENT AND STRUCTURE OF MESO-SCALE VORTICES ON THE TIBETAN PLATEAU

E.A. Rasmussen (University of Copenhagen, Department of Geophysics, Juliane Mariesvej 30, DK-2100 Copenhagen O, Denmark)

During summer mesoscale vortices are among the most important rain bearing weather systems on the Tibetan Plateau. Occasionaly these vortices move east, away from the Plateau, and may cause disastrous, heavy rain over parts of China. Due to the scarcity of meteorological observations on the Tibetan Plateau, only little is known about these vortices. In the paper we will, based on results from an extensive series of numerical computer simulations using a high resolution limited area model (HIRLAM), discuss the formation, development and structure of the Plateau vortices. The model simulations indicate that a number of these vortices, contrary to what former believed, initially form as low-level, baroclinic waves. Following the initial development convective processes become increasingly important, although the basic baroclinic structure seems to persist throughout the lifetime of the vortices.

DIAGNOSIS AND NUMERICAL SIMULATION OF A HEAVY PRECIPITATION EVENT IN CATALONIA (SPAIN)

R. Romero, V. Homar, C. Ramis and S. Alonso (Meteorology Group, Departament de Física, Universitat de les Illes Balears, Spain)

A heavy precipitation episode, and subsequent floods, took place in Catalonia (northeastern Spain) on 9-10 October 1994. Most of the coastal raingauges recorded more than 100 mm, and extreme rainfalls exceeded 400 mm at some localities in the south of the region. We present a diagnostical study of the meteorological situation in which the deep and efficient convection developed. The main characteristic at low levels is a southerly low level jet advecting warm and humid Mediterranean air toward the Catalonia coast. At upper levels, a deep trough was present over the southwest of the Iberian Peninsula, producing strong southwesterly winds over the Spanish mediterranean coast and important upward forcing by its vorticity advection. The diagnosis also shows that the coastal topography could have exerted a significant role by focalizing convection. In order to determine the importance of topography for spatial and quantitative rainfall, a hydrostatic mesoscale model with parameterized moist convection has been applied.

THE INTERACTION BETWEEN UPPER AND LOWER-LEVEL POTENTIAL VORTICITY ANOMALIES IN TWO-DIMENSIONAL MODELS.

M.Saute (Université Blaise Pascal, Laboratoire de Météorologie Physique,URA CNRS D0267, 24 Avenue des Landais, 63177 Aubière Cedex, France)

The geostrophic momentum approximation is used to investigate the interaction between upper and lower-level tropospheric potential vorticity anomalies, by means of an inviscid, adiabatic and isentropic two-dimensional semi-geostrophic model.The model simulations are intended to address the possibility that an upper tropospheric PV anomaly, moving over a lower-level disturbance, can result in rapid surface cyclogenesis, as well as the possibility that the evolution of the upper tropopause depression and of subsequent stratosphere-troposphere exchanges are linked to the surface developments. The aim of this study is to define appropriate configurations particularly favourable to strong interactions.The baroclinic development is forced by the vertical shear of the geostrophic zonal wind. The initial state is defined given a continuous potential vorticity field, including an upper tropospheric PV anomaly, looking like a tropopause depression, and a lower-level one in the form of a surface pressure anomaly.

The circulation and turbulence structure in mesoscale atmospheric boundary layer over non-uniform !.

V.Shnaidman, S.Stepanenko, A.Tarnopolsky, I.Marinin
Odessa Hydrometeorological institute

A method of mesoscale atmospheric boundary layer (ABL) is based on the solution of non-stationary baroclinic closed system, which includes the hydrodynamics and closure equations in topography coordinates to determine the meteorological variables and turbulence parameters. The closure is carried out with the equations of turbulence kinetic energy and its dissipation rate and with Kolmogorov and Smagorinsky relationships for vertical and horizontal coefficients of turbulence. The data of network meteorological information objective analysis in mesoscale resolution near the underlying surface and also of radiozonde observations are used to formulate the vertical boundary conditions. The developed model is applied to the quantitative description of ABL processes in mesoscale over complex topography, urban, suburban and coastal terrain.

THE GAP WIND FRONT OVER A FROZEN LAKE IN A MOUNTAINOUS AREA:

A. Smedman (Department of Meteorology, Box 516, 75120 Uppsala, Sweden)

The flow regime over a frozen lake surrounded by high mountains is studied in a field experiment and simulations with a numerical boundary layer model. It is found that the wind field over the lake in winter is mainly characterised by two flow regimes: forced channelling and pressure channelling or the gap wind.

The gap wind flow, which can give winds in excess of the wind of the top of the disturbed boundary layer, is restricted to the lowest 500 m above the lake surface, drops in speed to zero just above that layer, changing to across wind direction higher up. Gap winds are found to require slightly stable stratification for their existence; strong stability forces the flow to go round the mountains rather than over, and neutral conditions give a turbulent wake in the lee of the mountains. The gap wind starts at any occasion as a sudden warm front approaching from either of the two along wind directions. It is argued that the relatively warmth of the 'gap wind air' is due to air originally flowing at mountain top height across the lake axis being gradually turned and accelerated along the synoptic pressure gradient while descending. It is demonstrated that the prerequisites for a gap wind to occur is not only that the geostrophic wind direction is within certain limits but also that the Froude Number is within certain, well defined limits. This means that for a specific gap wind speed, the temperature difference between the gap wind air mass and the pre-gap-wind air mass must be within certain limits.

AN ENHANCED RESOLUTION ANALYSIS SCHEME FOR THE ATMOSPHERE OVER COMPLEX TERRAIN

R. Steinacker, W. Pöttschacher, M. Dorninger (Institut für Meteorologie und Geophysik, Silbergasse 45/7, A-1190 Wien, Austria)

The present analysis scheme has been developed for an automatic and operational recognition of meso scale (meso β) atmospheric patterns over complex terrain. It is based on the determination of the local Laplacian of a scalar field variable. 2D-vector quantities can be treated as well if they are divided into the non divergent and the non rotational part. Due to the irregular spacing of observations and their specific situation with respect to topography (i. e. stations in valleys or basins, on slopes, passes, mountain ridges or peaks) the analysed field usually is very rough. Conventional analysis schemes tend to treat this roughness as noise and smooth it out. Considering the fact that topography actually produces small scale structures of considerable amplitudes these disturbances which are caused by thermal (i. e. elevated heat sources) as well as dynamical (i. e. forced flow over and around the obstacle or blocking) effects of mountains are modelled with the aid of a very high resolution digital terrain data set (horizontal resolution less than 1 km). The modelled thermal and dynamical topographic „fingerprints" are finally used to fit the observations (again the Laplacian) by a mean square method. The resulting fields allow a resolution which is considerably higher than by using observations solely and hence presents a powerful downscaling method. The application of the method in a climatological mode allows in addition to detect even small systematic observational errors.

MEASUREMENTS OF WIND FIELD ON AN EDGE OF A MOUNTAIN RIDGE

J.Svoboda, J.Stekl and P.Zacharov (Institute Atmospheric Physics, 141 31 Prague 4, Czech Republic)

Two field experiments were realized in years 1995-1996 in the Erzgebirge mountain area (north-west part of the Czech Republic). The experiments were aimed to study a variability of the wind speed along a flat mountain ridges. This activity was evoked by tasks associated with optimal location of the wind turbines. Wind velocity was measured simultaneously in two different domains. The horizontal distance between these domains was about 3 km. The first one was located around a small hill (100 m height above surroundings) close to a south-east edge of the main mountain ridge. The second one was selected on the relative flat part of the main mountain ridge, again close to the same edge of the ridge. A horizontal variability of the wind speed between these two areas is studied. It is shown that the ratio of the wind speeds (between two tested domains) essentially depends on wind direction. Experimental data are preprocessed in such a way to serve for validation of numerical models. The second field experiment was oriented to measurements of a detailed structure of the wind field at the second (flat) domain.

PHYSICAL REASONS FOR STRONG HORIZONTAL GRADIENTS IN NOCTURNAL OZONE CONCENTRATION PATTERNS

U. Uhrner, B. Vogel and F. Fiedler (Institut für Meteorologie und Klimaforschung, Forschungszentrum Karlsruhe / Universität Karlsruhe, Postfach 3640, D-76021 Karlsruhe)

It is a well known fact that large differences in ozone concentrations occur during night time in the regional scale close to the surface. Titration of ozone by nonuniform spaced NO emissions and spatial differences of the interaction of advection, turbulent diffusion and deposition are followed by horizontal gradients of the ozone concentration. Numerical simulations with the nonhydrostatic mesoscale model system KAMM/DRAIS were carried out to study how far the nocturnal features of the temporal variation of the ozone concentration can be explained neglecting chemical transformations of ozone and therefore also the impact of emissions. A cross section of the Upper Rhine Valley in the area of Strasbourg was chosen as model domain. Taking into account only physical processes it is found that several observed features of the nocturnal ozone distribution are reproduced to a large extend. An important feature is that the reduction of the ozone concentration in the valley reaches heights up to 500 m above surface in the center of the valley. It will be shown that this is caused by positive vertical velocities in the center of the valley. These positive vertical velocities have an influence on the temperature profile and therefore on the mixing capability of the nocturnal boundary layer.

A STUDY OF THE MESOSCALE CLIMATOLOGY OF THE STABLE BOUNDARY LAYER IN COATS LAND, ANTARCTICA, USING INFRARED SATELLITE IMAGERY.

M. J. Varley, J. C. King, T. Lachlan-Cope
British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET, UK.

Katabatic winds originating in the Coats Land region of eastern Antarctica seldom propagate over the adjacent Brunt Ice Shelf. In an attempt to understand the local dynamics of this katabatic flow infrared satellite imagery covering Coats Land and the Brunt Ice Shelf, were examined together with daily radiosonde balloon flights for the British Antarctic Survey's Halley station during clear sky days in 1993 and 1995. Temperature data from each source were analysed to produce a mesoscale climatology of the stable boundary layer in this region. Satellite data indicate the presence of a 'thermal belt' on the continental slope at a height comparable to the top of the surface inversion over the ice shelf. Above this the surface lapse rate is close to dry adiabatic whilst the free air lapse rate is weakly stable all year round apart from summer. Inversion intensity and thermal belt strength vary dependently throughout the year. The available data have been used to assess the relative importance of some of the forces that control the regional katabatic flow.

CORRELATION OF FLOW IN DIFFERENT VALLEYS

R. O. Weber and P. Kaufmann (Paul Scherrer Institute, CH-5232 Villigen PSI, Switzerland)

The atmospheric near-surface flow over complex topography, and mainly in areas with many valleys, is strongly influenced by boundary conditions and is often channeled. Channeling here means that only two preferred wind directions, up- or down-valley, occur. It is our aim to define a measure that allows to quantify to what extent the up- and down-valley flows in different valleys are correlated. For scalar variables, the linear correlation coefficient has proven very useful for a quantitative description of relationships between different variables. For a vector quantity like a wind vector or directional data like wind direction, the definition of a correlation coefficient is much more involved. Many different definitions were proposed for vector correlation and directional correlation. As we are interested in flows with strong channeling, we define a new simple correlation coefficient. It is demonstrated by application to a model of channeled flow that the new correlation captures the flow features in the case of channeling better than other correlations taken from the literature. The new correlation coefficient is used to classify stations in a mesoscale network of anemometers in complex terrain. The stations can be grouped into classes with similar behavior of the channeled flow. Stations belonging to the same class are not necessarily at nearby locations. It is not the horizontal distance, but rather the orographic features and the altitude of the station locations that determine whether two stations belong to the same class and therefore show similar behavior of wind directions.

NORTH ATLANTIC OSCILLATION TYPE AT 500 HPA LEVEL WITH COMPARISON TO NAO INDEX

J. Wibig (Dept. of Meteorology and Climatology, University of Łódź, Lipowa 81, 90-568 Łódź, Poland)

The mean monthly values of 500 hPa geopotential heights over Europe and North Atlantic (defined at 80 points of geographical net) were transformed using EOF and varimax rotation to sets of orthogonal variables. These new variables can be interpreted as a characteristic circulation types at 500 hPa level. In each month one of these types corresponds with North Atlantic Oscillations. The variability with time of these types were compared with normalised pressure differences between Ponta Delgada and Stykkisholmur (called NAO index). The correspondence is very high, specially in winter months (correlations of the range 0.8). The maps of loadings were prepared and their interannual variability was analysed. It corresponds with seasonality of two main centres of action: Icelandic Low and Azorian High.

VERTICAL STRUCTURE OF MOUNTAIN WAVES, AND THE EFFECT OF THE TROPOPAUSE.

R.M. Worthington and L. Thomas (Department of Physics, University of Wales, Aberystwyth, Dyfed, SY23 3BZ, U.K.)

Measurements of the vertical wind by VHF radar allow mountain waves to be examined with fine height and time resolutions, and showing the differences in vertical structure associated with trapped or untrapped waves. This study is based on VHF radar measurements of vertical and horizontal wind velocities and echo power, and radiosonde measurements of the temperature height profile. The upward propagation of mountain waves into the stratosphere is investigated with reference to the Scorer parameter profile in the troposphere, and the change in Brunt-Väisälä frequency at the tropopause. Several large-amplitude mountain-wave events, where the wave phase remains nearly constant throughout the troposphere, appear inconsistent with wave trapping below a minimum in the Scorer parameter. Partial reflection at a sharp tropopause may be involved.

AN OBJECTIVE ANALYSIS SCHEME DIFFERING FROM THE ROUTINE

Xiaoping Zhong (Weather Office of Chengdu Regional Meteorological Center)

Objective analysis methods have been playing an important role in diagnositic analysis and numerical modeling since 1960's. But almost none of them does not need special limitations or prerequisites that are from mathematics, geophysics, meteorology, etc. Otherwise, it is demanded generally that there are more datum spots and higher homogeneity of spot distribution in given region. In fact, it is hard to meet the needs in the real atmosphere, especially over a large region. So a new scheme is presented here. Its basic idea is to highlight the importance of data from the nearest spot by using an appropriate weight function. There is always a shortest distance between datum spots in the given region. For convenience, let's call it as 'Basic Unit'. The weight function is chosen in order to get such a result that a spot with a distance to the grid point within one Basic Unit can receive a much larger weight than a spot with a distance between one Basic Unit and two Basic Units, so the later could be ignored relative to the former, and so on. By using of this weight function, the scanning radius is not used any more, and the limitation of the biggest number of datum spots has no use, too. In any region with different density of datum spots, 4-6 spots are enough for a good result. Another key point is to choose a special distance, called 'Ignoring Unit', according to the Basic Unit and grid size. If the distance between a grid point and the nearest spot is less than the Ignoring Unit, the value of an element at that spot will be used as the value at the grid point directly. It can improve the quality of the highest and lowest center analyzed significantly. Under those prerequisites, this scheme can lead to a good result for even an element that has a large spatial nonuniformity, such as rainfall, or in a region where the density of datum spot changes greatly.

PRECIPITATION CHARACTERISTICS OF MESOSCALE CONVECTIVE COMPLEXES IN PEOPLE'S REPUBLIC OF CHINA IN CONTRAST WITH THAT IN THE UNITED STATES

X.P.Zhong(Weather Office of Chengdu Regional Meteorological Center, Chengdu, Sichuan 610072, People's Republic of China)

Eastern region of the Tibetan Plateau, People's Republic of China, is a place where mesoscale convective complexes (MCCs) appear frequently. Here main precipitation characteristics of MCCs in P.R.C. are discussed in contrast with that in the U.S. In P.R.C., 30% to 50% of heavy rainfall (>10mm/h) is caused by MCCs. On average, MCCs produces a rain volume of 2.73 km during their life cycle. Rainfall from MCCs has obvious diurnal variation with the time of maximum at 03LST and minimum at 17LST, 3-4 hours later than U.S. MCCs. During the life cycle, rain volume from MCCs reaches the maximum at the intersection of the developing and mature stages while the strongest rain intensity appears in late initialing and early developing stages. In the initialing stage, rain area coverage increases from a small proportion to about half of the cloud anvil, and almost keep the same percentage through the developing and the mature stages. Some remarkable differences have been fund between the MCCs formed in P.R.C. and U.S. The major rain area of the former is located in the front part with respect to the general direction of MCC movement. The proportion of rain area under the cloud anvil is much larger in Chinese MCCs than U.S MCCs The property of transformation from convective to stratiform precipitation during the MCC life cycle is even more obvious.

ST19/OA11 Open session on mesoscale studies

02 Mesoscale transport of pollutants

Convener: Schaller, E.H
Co-Convener: Mikkelsen, T.

ON THE IMPORTANCE OF AEROSOL PHYSICS AND CHEMISTRY FOR REGIONAL MODELLING; FIRST THREE-DIMENSIONAL RESULTS FROM A MODAL APPROACH.

I. J. Ackermann and H.Hass (Ford Research Center Aachen, Dennewartstr.25, D-52068 Aachen, Germany)

The physical characteristics of tropospheric aerosols have to be considered in complex regional chemistry transport models in addition to aerosol chemistry, to obtain a more realistic description of those atmospheric processes that are influenced by aerosols. Hence, a modal approach for modelling coupled aerosol dynamics and chemistry which is fast enough for the use in complex Eulerian transport models is described.
MADE (Modal Aerosol Dynamics model for EURAD) treats aerosol chemistry in the sulfate-nitrate-ammonia and water system. Particle sizes are calculated for two lognormal modes under consideration of nucleation, coagulation, condensation as well as size dependent dry and wet deposition and cloud interactions. First results from a coupled system consisting of MADE and CTM (the chemistry tranport model of EURAD) will be presented. Additionally we will try to identify the most important needs for the future development of this aerosol modelling system.

ON THE MODELLING OF AEROSOL AND PHOTOCHEMICAL SMOG IN BOHEMIAN BASIN

J. Bednar, J. Brechler, T. Halenka (Department of Meteorology and Environment Protection, Faculty of Mathematics and Physics, Charles University, V Holesovickach 2, Prague, Czech Republic)

The transport of air pollution on the regional scale (Bohemian region) is presented. The results of Charles University model for the imission assessment are used to give information on the concentration and deposition fields of aerosol particles. The different spectra of particle size are taken into account. This version of model is based on plume principle and it can be solved both in case of climate studies and actual episodes. The estimation of the real episodes can be support with the computation of other important chemical compounds (nitrogen compounds, VOC's, ozone, etc.) using the new version of the model based on so called puff principle. This version of the model is discussed in more details.

TESTING DIFFERENT PBL PARAMETERIZATIONS FOR MODELLING TRANSPORT AND DISPERSION - VALIDATION FROM THE CHERNOBYL ACCIDENT

Joergen Brandt 1,2), Torben Mikkelsen 2), Soeren Thykier-Nielsen 2) and Zahari Zlatev 1)
1) National Environmental Research Institute, Department of Atmospheric Environment, Frederiksborgvej 399, P.O. Box 358, DK-4000 Roskilde, Denmark.
2) Risoe National Laboratory, Department og Meteorology and Wind Energy, Frederiksborgvej 399, P.O. Box 358, DK-4000 Roskilde, Denmark.

A tracer model for studying transport and dispersion of air pollution caused by a single but strong source is under development. The model is based on a combination of a Lagrangian meso-scale model (RIMPUFF) and an Eulerian long-range transport model (DEM). The Lagrangian model is used in the area near the source to calculate the initial transport and dispersion of the release and the Eulerian model is used for long-range transport calculations in the whole model domain. The meteorological meso-scale model MM5V1 (EURAD-version) is used as a meteorological driver for the transport model. Model simulations from the Chernobyl accident that illustrates the difference of using analyzed fields directly in the tracer model or using the meteorological driver, will be shown. Also different parameterizations of the mixing height and vertical exchange are compared. 2-D and 3-D visualization techniques are important tools for the development and validation of the model results. 2-D and 3-D visualizations together with comparisons with measurements will be shown for Chernobyl.

THE IMPACT OF TRANSPORT FROM NORTH AMERICA ON THE CHEMICAL SPECIES DURING THE NARE 1993 CAMPAIGN, NOVA SCOTIA (CANADA).

E.Buisson, N.Audiffren and N.Chaumerliac (Laboratoire de Météorologie Physique, CNRS/OPGC, Université B. Pascal, 24 Av des Landais 63177 Aubiere France).

Profiles of O_3, SO_2 and non-seasalt particules SO_4^{--} over the ocean near Nova Scotia, Canada are determined from in-situ measurements made during the 1993 North Atlantic Regional Experiment (NARE). 3-dimensional air back trajectory analyses have shown the high frequency of flow at 925 mb and aloft coming from regions of potentially high anthropogenic sources (North America) and the dominance of flow near the surface originated from maritime regions. Moreover, during the period of Sept. 5-7th, a stratocumulus layer has been formed below 800 m and is going to interact with the chemical products.
The approach used is to assess the impact of clouds on photochemistry. In this aim, using a chemical gas-aqueous phase module coupled with a mesoscale meteorological 2D model (CSU/RAMS), including microphysical processes, and considering variable photolysis rates modified by the presence of clouds, we simulated an episode (Sept. 7th 1993) taken from the NARE campaign. To account for emission flow from the continent, we introduce fluxes for the chemical species on the western boundary in our simulation based on previous studies over the site.
Because of H_2O_2 profiles show a different behavior from the others, hydogen peroxide retains particular attention with the aim of evaluating the relative contributions of varying photolysis rates and of the destruction with SO_2 in aqueous phase.

MODELIZATION OF THE DISPERSION OF POLLUTANT IN SEA BREEZE FLOW UNDER LARGE SCALE WINDS USING A PARTICLE MODEL.

J.Camps, J.Massons (Lab. Física Aplicada, Universitat Rovira i Virgili, P.Imperial Tarraco, 1, 43005, Tarragona, Spain)
and M.R.Soler (Dept. Astronomia i Meteorologia, Univ. Barcelona, Avda. Diagonal 647, 08028 Barcelona, Spain).

An hydrostatic three-dimensional meteorological model (Nickerson et al., 1986) was coupled with a lagrangian particle model (Massons et al., 1996) for analyzing the dispersion of pollutant released by a petrochemical plant on a coastal area considering a constant large-scale wind. The numerical experience covers two complete daily cycles. Results obtained include the overall distribution of particle concentration in each mesh point of the computational domain ($\Delta x=\Delta y=2.5$ km and 33 levels in height) at each time step (2.5 s for the meteorological code and 50 s for the particle model). The computed meteorological data are compared with measured data, both in surface and in height (using a SODAR Doppler). Computed and measured ground level concentration are compared as well. Authors acknowledge the computer resources provided by CESCA and the finantial support of the Departament de Medi Ambient (Generalitat de Catalunya).

AIR POLLUTION STUDIES FOR WORST CASE EVALUATION IN THE PLOIESTI-PRAHOVA INDUSTRIAL AREA BASED ON THE RIMPUFF DISPERSION MODEL

D. Gultureanu[1)], B. Gultureanu[2)], Torben Mikkelsen[3)], Soeren Thykier-Nielsen[3)]
[1)] Department of Physics, Petroleum-Gas University of Ploiesti, Romania
[2)] Department of Computer Sciences, Petroleum-Gas University of Ploiesti, Romania
[3)] Department of Meteorology and Wind Energy, RISOE National Laboratory, Denmark

The paper presents the results of research work started at RISOE National Laboratory, Denmark and continued at Petroleum-Gas University of Ploiesti, Romania regarding application of the real-time episode dispersion model RIMPUFF to the Ploiesti-Prahova industrial area with the motivation to understand and quantify severe air pollution scenarios of ground level air concentrations resulting from the different sources of petro-chemical origin located in the industrial area

Records of one hour mean wind and temperature measurements were taken from the nearby Ploiesti meteorological station and used as input data to the combined flow and diffusion model LINCOM/RIMPUFF for a sequence of severe emissions and wind flow episodes.

Sources were considered inside the Ploiesti industrial area. For the simulations we considered a 50 km x 50 km domain modelled on a 150 x150 grid.

The study encounters some worst case dispersion scenarios in the area, in good agreement with local observations.

On the question of the atmosphere pollution distribution (application for the high relief area)

Z. Khvedelidze (Tbilisi State University, Geophysics department, 3, Av Tshavtshavadze, 380028, Tbilisi, GEORGIA)
T. Bibilachvili (Tbilisi State University, Geophysics department, 3, Av Tshavtshavadze, 380028, Tbilisi, GEORGIA)

The development and distribution of polluted zones (caused by different sources) in the earth atmosphere, is derived from equation of the turbulence diffusion. In the case when the wind velocity component along the pollution distribution and diffusion coefficients do not depends on the altitude, the solution is given by an exponential function. Concentration of the pollution agents depends on the source capacity, wind velocity and air turbulence.
The theoretical results were tested for meteo conditions in Georgia, using the numerical modeling of stationary and nonstationary regimes.
We conclude that pollution agents distribution decrease dramatically crest to the wind velocity, its distribution becoming nearly symmetrical.

MESOSCALE MODEL OF IMPURITIES TRANSFER

E.Ljoubimova, Pavel N.Belov (Moscow State University, Meteorology Department)

Numerical mesoscale model of air pollution transport in the interior boundary layer is suggested. The model takes into account all main physical factors, influence to change and transformation of impurities, atmospheric stratification.Trajectories of particles are calculated with main equations of hydrothermodynamics using wind and atmospheric pressure data. The model is applied for assessment of concentrations of such harmful ingredients as sulphur dioxide, nitrogen oxide, carbon dioxide. The model is run for northern region of Russia, which is situated in vicinity of Norilsk mining plant, famous as the largest source of sulphur dioxide. The changes of concentration along the plum are calculated with consideration for dry and wet deposition with different direction and velocity of the winds for 4 seasons.The concentration under unfavourable meteorological conditions is computed as well. We have shown that under these conditions concentration of untoward constituents is much more than tolerable concentration and impurities are spread just by 10 km from the source and are deposit in this region.
We have applied the model for typical town in the European part of Russia (Vladimir). Concentration under unfavourable meteorological conditions here may exceed tolerable concentration by 2.5 times even in this relatively unpolluted town.

A MIXED-SPECTRAL MODEL FOR MESOSCALE AIR POLLUTION DISPERSION CALCULATIONS

M. Kaasik and H. Kaasik (Tartu University, Tähe 4, Tartu EE-2400, Estonia)
R. Rõõm (Tartu Observatory, Töravere EE-2444, Tartumaa, Estonia)
K. E. Grønskei (Norwegian Institute for Air Research, Instituttveien 18, N-2007 Kjeller , Norway)

The fast Fourier transformation (FFT) in horizontal dimensions, applied to the K-theory equation of stationary turbulent diffusion (method earlier used by Beljaars et al for boundary layer flow without admixture diffusion). When applied to the boundary layer over uniform terrain, this approach reduces considerably the range of system of equations to be solved in the numerical scheme (with respect to a gridpooint model). As a result, higher spatial resolution is achieved by equal computing time. The non-physical oscillations, appearing near the points of discontinuity of concentration field (e. g. point sources) due to the FFT, are reduced by the integral transformation of main equation. The similarity theory is used for boundary-layer parametrization. The wind shear effect is included. The model output is compared to the results of a dispersion experiment, carried out by the Norwegian Institute for Air Research (NILU) in a suburb landscape at Lillestrøm 1987. Sonic anemometer and gradient data are used in model evaluation. The intercomparison with models designed at NILU is in progress.

SIMULATIONS AND SENSITIVITY STUDIES WITH THE 'REMO' CEMISTRY MODELLING SYSTEM

Bärbel Langmann, Ralf Podzun and Daniela Jacob (Max-Planck-Institut für Meteorologie, Bundesstr. 55, 20146 Hamburg, Germany)

In our contribution we would like to present the latest developments of the global, regional and local scale model hierarchy ECHAM-REMO-GESIMA for the simulation of the troposphere dynamics as well as transport, transformation and deposition of photochemical and acidifying chemical species. The main focus is to couple the models with different scales by "nesting" of the dynamical and chemical variables and to incorporate chemical modules "on-line" in the dynamical circulation models to identify chemical-dynamical feedback mechanisms. Besides the "on-line"-branch, the "off-line"-methodology to determine trace gas distributions in the troposphere has already been established for the regional scale model REMO. Simulations and sensitivity studies of the TRACT'92 episode with a part of the model hierarchy will be shown.

NUMERICAL SIMULATION OF THE TRANSPORT OF ATMOSPHERIC TRACE GASES DURING SEA-BREEZE CYCLES IN THE REGION OF SFAX (TUNISIA)

Ahmed Maalej , Karsten Suhre, Robert Rosset (Laboratoire d'Aérologie (UMR CNRS/UPS 5560), O.M.P., 14, Avenue Edouard Belin, 31400. Toulouse, France)

The transport and diffusion of pollutants in the region of Sfax is studied in typical conditions of sea-breeze development. This local circulation dominates the flow in summer, favouring inland transport of pollutants from the coast. The characteristics of the transport of gaseous pollutants in sea-breeze circulations are investigated using a detailed coupled transport/chemistry mesoscale model (MESONH). We report numerical results of this coupled model about the transport and redistribution of trace gases during successive sea-breeze cycles.

BUDGET CALCULATIONS OF PHOTO OXIDANTS FOR A SUMMER-SMOG EPISODE OVER EUROPE

M. Memmesheimer, H Feldmann, H.J. Bock, A. Ebel and H.J. Jakobs (University of Cologne, Institute for Geophysics and Meteorology, EURAD, Aachener Str. 201 209, 50931 Cologne, FRG)

The EURAD model is applied to a summer smog episode in July/August 1990 to calculate the transport, deposition and chemical transformation of photo oxidants and their precursors in the troposphere over Europe.

The contribution of the different terms in the continuity equation are analysed for the summer smog episode considered Different regions in Europe are investigated and characterized on the basis of mass budget calculations. The processes considered are: transport due to large scale atmospheric circulation systems, transport due to turbulent mixing, photochemical loss and production, dry deposition, and cloud processes. The sensitivity of the model results and the budget analysis to emissions and boundary values are investigated. The importance of the different processes are compared for different photo oxidants and their precursors. It could be shown that large-scale subsidence in the high-pressure system, which governed the circulation during that summer-smog episode, play an important role for the mass budget of ozone.

MESOSCALE MODELLING OF SO_2-TRANSPORT IN THE "BLACK TRIANGLE" AREA

A. Münzenberg-St.Denis and R. Göldner, E. Renner, R. Wolke (Institute for Tropospheric Research, Permoserstr. 15, D-04303 Leipzig, Germany)

Even if air quality has improved considerably in eastern Germany over the last couple of years, the problem of e.g. SO_2-emission is still an issue especially in the area of southern Saxony (Erzgebirge). Monitoring transport and distribution of SO_2 originating from point and area sources can be supported using the results of mesoscale transport models as additional information.
This paper presents results for SO_2-transport as modelled with the mesoscale transport model METRAS for different meteorological conditions. The simulations refer to the area of the so-called "black triangle". Sensitivity of the results due to different horizontal resolutions as well as to nesting procedures is discussed.

SOURCES OF SO_2, NO_x, SO_4^{2-}, AND NO_3^- IN THE AIR OF LOGROÑO, A SPANISH EMEP STATION

A. Rúa (Deparment of Statistic and Operative Investigation II. Complutense University, Campus de Somosaguas, 28223, Madrid, Spain)
E. Hernández (Deparment of Air Physics Complutense University, Ciudad Universitaria, 28040, Madrid, Spain)
L. Gimeno (Center of Meteorological Trainig. Spanish National Meteorology. Ciudad Universitaria, 28071, Madrid, Spain)
J. Diaz (C.U.S.P., 28006, Madrid, Spain).

The sources of SO_2, NO_x, SO_4^{2-} and NO_3^- in the air of a remote station belonging to the EMEP (European Monitoring and Evaluation Programme) network are studied.

To do that we used information about trajectories toghether with the CPF functions (Conditional Probability Functions) Results suggest that the Mediterranean area is the most important source of these pollutants, being also the North of Africa and the South of France important sources for any of the pollutants. The data used correspond to the daily of air composition from January 1989 to December 1994.

TRENDS AND SEASONAL VARIATION OF SO_2, NO_x, SO_4^{2-} AND NO_3^- CONCENTRATIONS IN THE AIR OF LOGROÑO.

A. Rúa (Deparment of Statistic and Operative Investigation II. Complutense University, Campus de Somosaguas, 28223, Madrid, Spain).
E. Hernández (Deparment of Air Physics. Complutense University, Ciudad Universitaria, 28040, Madrid, Spain)
L. Gimeno (Center of Meteorological Trainig. Spanish National Meteorology. Ciudad Universitaria, 28071, Madrid, Spain).
J. Diaz (C.U.S.P., 28006, Madrid, Spain).

We have studied the trends and seasonal variation of the concentrations of SO_2, NO_x, SO_4^{2-} and NO_3^- in the air of a Spanish remote station belonging to the EMEP (European Monitoring and Evaluation Programme) network.

This study has been combined with a study of the main geograhycal sources of these pollutants. So we have also done a temporal analysis dividing our sample in subsamples according to the origin of the trajectories. An analysis of the episodicity of high concentrations of these pollutants is also done. The data used correspond to the daily of air composition from January 1989 to December 1994.

VALIDATION OF A PARTICLE DISPERSION MODEL USING DATA FROM THE ETEX EXPERIMENT

A. Stohl (Universität für Bodenkultur, Institut fuer Meteorologie und Physik, Türkenschanzstrasse 18, A-1180 Vienna, Austria)

A Lagrangian particle dispersion model, FLEXPART, was recently developed. It is based on model level data from the numerical weather prediction model at the European Centre for Medium Range Weather Forecasts (ECMWF) and is designed to simulate long-range transport processes. It was applied to calculate the transport of an inert tracer released during the first ETEX experiment. The dispersion of the tracer cloud was well simulated, but the model overestimated measured concentrations, especially during the initial phase after the release. Neglection of cloud venting by the model is likely to have caused this bias.

FOG MODELING IN THE EURAD-MODEL – A SENSITIVITY STUDY

J. Tippke, M. Memmesheimer, H. Feldmann, H.J. Jakobs and A. Ebel (University of Cologne, Institute for Geophysics and Meteorology, EURAD, Aachener Str. 201-209, 50931 Cologne, Germany)
R. Forkel (Fraunhofer-Institut für Atmosphärische Umweltforschung Kreuzeckbahnstr. 19, 82467 Garmisch-Partenkirchen, Germany)

A modified version of the EURAD-modeling system has been coupled with an one-dimensional radiation fog model in order to investigate the impact of fog on concentration and deposition fields over southern Germany during an episode from the 15th to the 16th of September 1992. Liquid-phase chemistry transformations and the effects on sedimentation, deposition and the actinic flux are considered within the CFM (Chemical Fog-Module).

Apart from already existing cloud-treatment in the EURAD-System an additional path of sulphate-production and deposition is developed. The resulting SO_2-concentrations are considerably lower in the fog case compared to the base case without fog chemistry. Moreover the photochemical active species are affected by changes in photolysis rates. Not only concentrations of anorganic species such as O_3 but also concentrations of organic species such as Carbonyles reflect the impact of fog on the actinic flux. Due to the predicted fog water concentration the total amount of deposited species increases, e.g. the average amount of deposited H_2SO_4 rises from 6.5 $\frac{g}{ha}$ in the base case to 19.4 $\frac{g}{ha}$ in the fog case.

THE PLUME OF VIENNA - COMPARISONS BETWEEN AIRCRAFT MESUREMENTS AND PHOTOCHEMICAL MODEL RESULTS

G. Wotawa and A Stohl (Universitaet fuer Bodenkultur, Institut fuer Meteorologie und Physik, Tuerkenschanzstrasse 18, A-1180 Vienna, Austria)
B. Neininger (MetAir AG, Laenggstr. 19, P.O Box 9, CH-8308 Illnau, Switzerland)

In July and August 1995, aircraft measurements were done during episodes of enhanced ozone concentrations around the city of Vienna. One aim of these measurements was to record position, extent and intensity of the urban ozone plume in the lee of the city. For all measurement days, simulated fields of ozone and other pollutants were calculated on a 10x10 km grid covering the region of interest. The simulations were done using the IMPO-model, a Lagrangian box model recently developed at our institute. The back trajectories and meteorological data used by the IMPO-model are based on the data of the ECMWF weather prediction model supplemented by observations from meteorological stations all over Europe. The trajectories around Vienna were corrected by a downscaling approach based on the dense surface wind observation network in Eastern Austria.

The horizontal position of the plume, especially its direction relative to the city centre as recorded by the aircraft measurements, is well reproduced by the model Downscaling of ECMWF trajectories increases the model performance considerably. The ozone production in the plume is also well simulated Generally, the IMPO-model performs well in reproducing the position and intensity of the urban plume of Vienna.

ST20/OA20 Storm track and cyclone variability

Convener: Ulbrich, U.
Co-Convener. Valdes, P.J.

MECHANISMS FOR MID-LATITUDE CYCLONE DEVELOPMENT

Jake Badger and Brian J. Hoskins (Department of Meteorology, University of Reading, UK)

The work presented explores the dependence of perturbation structure, location and scale on the linear evolution in a series of initial value problem experiments. An Eady model set-up is used to investigate the simplest quasi-geostrophic behaviour. Perturbations which are confined both vertically and horizontally in streamfunction yield the greatest kinetic energy growth rates. Growth rates in excess of the fastest growing normal mode are achieved without any phase tilt with height. This can be explained using PV ideas. The initial configuration, a primary PV anomaly region flanked above and below by PV of the opposite sign, is dismantled by the sheared basic flow. The resulting unshielding of the primary PV induces flow over a larger part of the domain. Experiments performed using a primitive equation model demonstrate similar behaviour, but in this case upward propagation of Rossby waves in the interior provides a significant mechanism for growth over the first day or so. The perturbation scale associated with the upward propagation of wave activity is investigated in zonally symmetric and asymmetry basic flows If boundaries are involved from the beginning this large transient growth is suppressed. However at later times they are vital for the continuing near normal mode growth. The perturbations and evolution share properties of optimal modes and singular vectors. Here, the emphasis is on understanding the physical basis of these properties.

ON THE MODIFICATION OF EXTREME WIND SPEEDS AT THE BALTIC COAST OF MECKLENBURG-VORPOMMERN

Bj.-R. Beckmann and G. Tetzlaff

Institute for Meteorology, University of Leipzig
Stephanstraße 3, D - 04103 Leipzig

In the scope of the climate research program of the Baltic Coast of Mecklenburg-Vorpommern the sites of Wustrow and Warnemünde were examined with respect to extreme winds. The time series were corrected for the local effects to get a long and homogenous time serie from 1880 to 1993. The time series of the 1, 10 and 50 % percentiles derived from five years distributions of the long time serie show no change in the storm frequency and the average wind speed in the past 100 years. To get some information about the modification of the barochinicity the annual thermal wind speed between the 700 and the 850 hPa-level of Greifswald was determined. The investigation shows no significant change of the thermal wind speed since 1949. These two different investigations give no indications for a change in the frequency of extreme wind speeds in the past.

Interpretation of Eulerian storm track diagnostics

U. Burkhardt and I.N. James (Department of Meteorology, University of Reading. PO Box 243, Reading, RG6 6BB, UK.)

The intensity of storm tracks is commonly measured in terms of Eulerian diagnostics such as the eddy kinetic energy which is associated with cyclones moving with a certain phase speed. This phase speed is not only dependent on the cyclone itself but also on the background flow in which the cyclone is embedded. Hence, Eulerian storm track diagnostics such as eddy kinetic energy of the high pass filtered fields do not only pick up the variability in eddy activity or the variability in the structure of cyclones, but also the temporal and spatial changes in the backgrouud flow. Especially in areas of weak zonal flow (over the continents) and in times of low wind speeds (blocking) this impact of the background flow may be significant. A method to eliminate the dependence of the Eulerian storm track diagnostics on the background flow, based on Doppler shifting of the eddy activity, is proposed and tested.

STORM TRACK AND LOW FREQUENCY VARIABILITY SVD ANALYSIS

A. Carillo, C. Pona, P.M. Ruti and M. Sciortino (ENEA-Italy)

Many authors have put in evidence a link between the slowly varying component of the circulation, mainly related to blocking events, and storm tracks activity; nevertheless the relationships between the low- and high-frequency components of the atmospheric circulation need further investigations.
Here we use a Singular Value Decomposition technique (SVD) to correlate storm tracks, defined as the 2.5-6 day bandpass filtered component of the 500-hPa height fields, with monthly mean wintertime fields.
The analysis has been performed on an observed dataset starting from January 1979 to December 1988 (ECMWF analyses) and then applied to an ensemble of AGCM simulations forced with prescribed SST for the same 10-years period.
The SVD analysis was performed in two separate regions, the Euro-Atlantic and the Pacific sectors, trying to verify the existence of different time-scales of atmospheric variability in the two regions. SVD analyses were applied both to monthly mean and seasonal mean time series in order to distinguish the interannual and intraseasonal variability.
Preliminary results show a strong correlation between storm tracks and sea level pressure in both sectors for observed and simulated data; it is also evident the presence of the teleconnection pattern in the correlation maps. The Atlantic observed variability appears slightly more pronounced than the Pacific one; while this behaviour is not evident in the simulated data.

DIABATIC HEATING IN STORMTRACK EDDIES OF PRESENT DAY AND 2*CO_2-FORCED CLIMATE

G. Hoffmann, P. Speth, U. Ulbrich (Institut für Geophysik und Meteorologie der Universität zu Köln, Kerpener Str. 13, D-50923 Köln, Germany) and E. Roeckner (MPI, Hamburg, Germany)

Different diabatic processes are affecting transient baroclinic disturbances in mid-latitudes. It is investigated if and how this influence changes due to increasing CO_2-forcing for boreal winter. Three dimensional distributions of heating rates are taken from the parameterized diabatic processes in the ECHAM4-GCM. Model runs for present day climate and a greenhouse scenario are considered. The direct effects of different diabatic heating processes on the mid-latitude transient baroclinic disturbances are estimated by local contributions to the generation of their available potential energy (GE_{TR}).
Large-scale latent heat release (LLH) in middle troposphere is the dominant process with respect to the tropospheric production of GE_{TR} in the mid-latitudes. In the Pacific maxima of local contributions of GE_{TR} due to LLH are generally located upstream of largest stormtrack activity. Both quantities are correlated with each other. For the Atlantic no such clear relationship is found.
In the scenario run the Pacific stormtrack maximum and the associated GE_{TR} contributions are shifted northward. The moderate increase of mean stormtrack intensity is not associated with significant changes of GE_{TR}. Over the Atlantic, the most prominent signal is a downstream extension of the stormtrack into Europe. It is accompanied with increased local contributions of GE_{TR} in the central North Atlantic. The effect over this ocean basin is associated with a local enhancement of mean meridional water vapour advection from the subtropics.

CONTROL MECHANISMS AND SEASONAL VARIATIONS OF STORM TRACKS IN MARS' ATMOSPHERE

J.L. Hollingsworth[*†] and R.M. Haberle[†] ([*]SJSUF/[†]NASA Ames Research Center, MS: 245-3, Moffett Field, CA 94035, USA)
J. Schaeffer (Sterling Software, Inc., Palo Alto, CA 94393, USA)

Midlatitude synoptic scale low-pressure cyclones and their accompanying frontal systems tend to develop, travel eastward, and decay preferentially within certain geographic regions commonly designated as storm tracks or storm zones. Like Earth, Mars is a rapidly rotating solid planet with a seasonally varying shallow atmosphere where traveling weather systems also occur. Further, both planets exhibit large-scale orography and, in a broadly defined context, continentality. Numerical simulations with a Mars global atmospheric circulation model suggest that northern storm zones can exist in early autumn through late spring. Band-pass filtered transient eddy variances/covariances become quite localized during winter and are strongest during early spring. Following weakening baroclinicity during the seasonal transition, the eddy activity rapidly weakens and the associated storm 'belt' shifts into high latitudes. Compared to Earth, where land-ocean thermal contrasts appear vital in the maintenance of storm zones, Mars' continental-scale orography can effectively localize its synoptic-scale weather activity. Experiments using only zonally symmetric topography indicate not only a zonally uniform storm belt but also the transient eddy activity becomes very enhanced and is significantly dominated by low-frequency modes. Given basic similarities between the two planets, detection and characterization of storm zones on Mars should provide insight into fundamental underlying mechanisms, particularly regarding the importance of surface mechanical and thermal effects.

A review of storm track mechanisms

B.J.Hoskins (Department of Meteorology, University of Reading, Earley Gate, PO Box 243, Reading. RG6 6BB. UK)

The term storm-track suggests that mid-latitude cyclones tend to be initiated in a certain region, move and grow long a limited quasi-longitudinal corridor, and decay in a certain region. The mechanisms that have been discussed for these various aspects of behaviour and the feedback of the cyclones onto the existence of the storm-track will be discussed. Implications for the variability of the N. Atlantic storm-track and possible changes in it due to anthropogenic effects will be drawn.

UNDERSTANDING MID-LATITUDE STORM-TRACKS IN A GENERAL CIRCULATION MODEL: REGRESSION ANALYSES AND BAROCLINIC LIFECYCLES

M. Kageyama and P. J. Valdes (Department of Meteorology, University of Reading, United-Kingdom)

To investigate the northern hemisphere winter storm-track representation in General Circulation Models (GCMs), we analysed some UGAMP GCM simulations in the following way: we first determined the characteristics (mainly wavenumber and phase-speed) of the weather systems in the runs using regression and lag-regression analyses. In a second step, we studied the linear growth-rate and phase-speed of perturbations applied to basic states from the GCM runs and characteristic of each storm-track. Non-linear lifecycles, using the UGAMP "simple" GCM, which has no parameterisations but the dynamical ones, have also been run to complete our linear study.
We used this method to study the Pacific and Atlantic winter storm-tracks in the UGAMP T42 GCM present day and Last Glacial Maximum (LGM) simulations run in the framework of the Palaeoclimate Modelling Intercomparison Project (PMIP). The LGM climate, constrained by huge ice-sheets over the continents and different sea-surface temperatures, sees significant changes in weather system development. This is most obvious from both approaches over the Atlantic, where LGM perturbations are broader and faster. Thus, studying the single mechanism of baroclinic development on basic states from GCM simulations appears valuable in understanding the storm track differences and this method will be used to analyse differences between other PMIP runs.

THE DIAGNOSIS OF ANALYSIS AND MODEL ERRORS IN THE NORTHERN HEMISPHERE STORM TRACKS

E. Klinker and F. Rabier (ECMWF, Shinfield Park, Reading,Berkshire RG2 9AX, UK)

The largest NH forecast errors in the medium forecast range occur in the storm track areas of the Pacific and Atlantic. A separation of analysis errors and model errors is normally a very difficult task. Over the oceans where the data density is particularly low analysis errors contribute to a large part to medium range forecast errors. Using adjoint integrations to minimize the day-2 forecast errors the dominant analysis errors can be estimated. Correcting the initial conditions based on the knowledge of these so called key-analysis errors, unstable error growth is substantially reduced and subsequent integrations reach a higher level of consistency than operational forecasts. Integrations from smaller errors in initial conditions therefore form an optimal basis for diagnosing effects from the diabatic processes. In particular beyond the optimization time of two days the integrations from modified initial conditions are used to diagnose the role of diabatic forcing for medium range forecast errors in the storm tracks. The diagnostic technique is based on tracing the redistribution of potential vorticity by diabatic processes.

Issues in determining storm track variability

I.N. James (Department of Meteorology, University of Reading, Reading RG6 6BB, UK

The variability of storm track intensity and length is likely to be a major element in the climatic variability of much of the mid-latitudes, especially of those regions located towards the downstream end of the stormtracks, such as western Europe. Attempts to describe or model such variability hinge on what measures of eddy activity are used to define a storm track. The usual approach, using time filtered Eulerian diagnostics can be misleading in several respects. Such Eulerian diagnostics will be compared with results based on identifying and tracking individual cyclone/anticyclone systems and with Hovmoeller plots. It will be shown that these different diagnostics lead to different pictures of storm track variability; an attempt will be made to reconcile these conflicting results.

Some comments on possible mechanisms for low frequency storm track variability will be included. These amount to an attempt to find a local parametrization of high frequency transients.

VARIATIONS OF CYCLONIC ACTIVITY OVER CASPIAN SEA REGION

I.I.Mokhov, V.A.Semenov and S.G.Priputnev (Institute of Atmospheric Physics, 3 Pyzhevsky, Moscow 109017, Russia)

Caspian Sea (CS) is characterized by large variations of its level. The CS level has risen on 2.5 m during two last decades. This closed Eurasian water reservoir with the catchment area about 3 million sq. kilometers can serve as a unique indicator of climatic variations. Hydrological cycle in the CS basin is related, in particular, to the North Atlantic and Mediterranean storm tracks. The analysis of observations shows the prominent change of sea-level pressure (SLP) field for the period of the CS level increase relative to the previous period of its decrease. The SLP trends found for some specific regions are related to the changes in atmospheric circulation and cyclonic activity. Characteristics of cyclonic activity in the middle troposphere and near surface over the CS basin are analyzed using different data for last decades. There is a correlation between variations of the cyclonic activity and precipitation over the CS basin. The connection between the regional cyclonic activity and global climate in interannual and interdecadal variability (including El Nino effects and variations of centers of action) is analysed.

NORTH ATLANTIC STORMINESS RE-ANALYSED: NO TREND DURING THE PAST 100 YEAR PERIOD

Torben Schmith and E. Kaas (Danish Meteorological Institute, DK-2100 Copenhagen Ø, Denmark)

A unique new data set consisting of quality controlled mean sea level pressure observations, 3 - 4 times daily, at more than 20 stations in the Northern European and North Atlantic Region has been compiled in digital form as part of the European WASA project. Most of the stations has an almost unbroken 100 year observational record. The pressure data in the WASA data set have been used to estimate the storminess. Here an analysis of storminess is presented which is based on slow variations in high frequency variability in the pressure data. Technically this is done by calculating the absolute 24 pressure tendencies at each observation time. This way of analysing the data, ensures a homogenous record. Different percentiles (50, 10 and 1) of the tendencies are then constructed for each season and year. The resulting time series of percentiles are remarkable stable, showing no overall trends in storminess. However, there are certain important decadal variations. The variations in the identified local storminess can be related to slow variations in the mean pressure patterns over the North Atlantic. A downscaling model is used to investigate if there are trends in this relationship which may reflect interesting variations in the 3 dimensional structure of the atmosphere, possibly related to external forcing of the atmosphere.

MECHANISMS OF ANTHROPOGENIC CHANGES IN NORTHERN HEMISPHERE WINTER STORMTRACKS

M. Sogalla, P. Speth and U. Ulbrich (Institut für Geophysik und Meteorologie der Universität zu Köln, Kerpener Str. 13, D-50923 Köln, Germany)

Anthropogenic changes in the regional distribution of synoptic activity are considered. Investigations focus on the role of baroclinicity and the relevance of upstream stormtrack activity to local stormtrack strength. The latter influence is assessed through the *spatial persistence* of the stormtracks, i.e. the spatial distance up to which stormtrack variations are temporally correlated. Both ECMWF analyses and a control simulation as well as a $3{\cdot}CO_2$-experiment with the Hamburg ECHAM3 climate model are examined.
According to ECMWF analyses, spatial persistence is highest in the lee of continental mountain chains and lowest in the eastern oceans. Particularly in the latter regions, stormtrack activity is correlated with baroclinicity.
In the control run, the mean stormtracks and baroclinic zones are reproduced realistically. Their interannual variability is underestimated especially over the Atlantic. The gross features of the interrelationship between baroclinic instability and stormtrack activity are reasonably well simulated.
In the $3{\cdot}CO_2$-experiment, a pronounced increase in spatial persistence is connected with both an intensification of mean stormtrack strength over the eastern oceans and an increase of interannual stormtrack variability over the western hemisphere. Changes in mean baroclinicity are additionally relevant to stormtrack signals over the Pacific while baroclinicity maintains its strength and role over the Atlantic. Possible causes for the increase in spatial persistence are discussed.

THE SEASONALITY OF THE NORTHERN HEMISPHERE STORM TRACKS

P. J. Valdes and **L. C. Shaffrey** (Department of Meteorology, University of Reading, Reading, U. K.)

Storm tracks can be defined as regions of transient eddy fluxes associated with localised regions of high frequency synoptic eddies. During the Northern Hemisphere Winter and Equinox seasons there are two localise d maxima of transient eddy fluxes, the Atlantic and Pacific storm tracks, but th eir seasonal behaviour is rather different. The Atlantic storm track is strongest in Winter, whereas the Pacific storm track is strongest in Spring and Autumn. It is not clear what mechanisms are responsible for the different behaviour of t he two storm tracks.
The present study aims to investigate the maintenance and seasonality of the Pac ific storm track within a simple GCM (Global Circulation Model). The GCM is constrained by restoring the zonal temperature field to an empiricall y determined restoration state, this restoration maintaining a chosen zonal temp erature field. Simple representations of latent heating, sensible heating, zonally varying surf ace friction and orography are included in the GCM.
The resulting DJF and SON Pacific storm tracks are similar to observations but t he observed seasonality of the Pacific storm track is not correctly reproduced. The possible reasons for the failure of the model to account for the seasonal va riation of the Pacific storm track will be discussed.

PREDICTION OF EXTRATROPICAL CYCLONES IN THE UKMO GLOBAL NWP MODEL

A. D. Van der Wal and S. F. Milton (Meteorological Office, London Road, Bracknell, Berkshire, RG12 2SZ, U.K.)

Accurate prediction of extratropical cyclones and their life-cycles is a crucial aspect of the performance of an NWP model. In this study, the aim is to objectively identify whether there are any *systematic* errors in the tracks and central pressures of individual cyclonic systems in the UKMO global NWP model, and to determine the relationship between these "stormtrack errors" and errors in the mean flow.
An objective cyclone tracking algorithm has been applied to five-day forecasts and corresponding analyses over the Atlantic region for the 90 days from 01/12/94 to 28/02/95 at 12-hourly intervals; forecast tracks are associated with their analysed counterparts and errors in position, speed and central pressure are calculated. Examples of individual systems are used to highlight systematic errors and potential deficiencies in the tracking procedure are also discussed. Mean results show that forecast tracks are generally too zonal, deepening lows are too shallow in the forecast, and filling lows are too deep.

AN OBJECTIVE CLIMATOLOGY OF NORTHERN HEMISPHERE CYCLONES AND ANTICYCLONES

Heini Wernli and David N. Bresch (Institute for Atmospheric Science, ETH Hönggerberg, CH-8093 Zürich, Switzerland)

Previous diagnostic studies of the climatology of baroclinic wave activity were based on two different approaches, and served respectively to identify the so-called "synoptic" and "dynamic" storm-tracks. The "synoptic" storm-track equates to the statistical distribution of the paths of cyclone centers as analyzed from sea-level pressure charts, whereas the "dynamic" storm-track relates to band-passed filtered variances of the geopotential height field. The relationship between the two fields is not straightforward; and indeed the "synoptic" storm-track is usually not represented as a mathematical field. This makes quantitative investigation difficult.
Here an alternative technique is introduced for the objective diagnosis of "synoptic" storm-tracks. It identifies closed isolines in the sea-level pressure field, and generates a field which is (within the cyclone) equal to the pressure difference relative to the value of the enclosing isoline. Using NMC analysis data from 1962-1992 monthly mean fields are derived for cyclones and anticyclones on the northern hemisphere. This permits a quantitative analysis of the inter- and intra-annual variability and of possible changes in the frequency, location and intensity of synoptic disturbances during this 30-year time period. Consideration is also given to the possibility of comparing the two types of storm-tracks, using EOF and SVD techniques.

THE VARIABILITY OF CYCLONE STRUCTURES: RESULTS FROM IDEALIZED NUMERICAL SIMULATIONS WITH INCREASING COMPLEXITY

Heini Wernli, Jürg Schmidli and René Fehlmann (Institute for Atmospheric Science, ETH Hönggerberg, CH-8093 Zürich, Switzerland)

Idealized model simulations of baroclinic wave development indicate that a range of dynamical and physical factors can significantly influence the structure of the resulting cyclones and fronts. Important dynamical factors are the earth's sphericity, the choice of the initial perturbation, and the shape of the jet-like basic state. The latter can be altered for instance through the addition of a uniform barotropic shear component, and this has been shown to exert a profound influence upon the nonlinear development of normal-mode perturbations.
In this study the effect of barotropic shear is further analyzed for the initial-value problem of upper-level induced cyclogenesis, using a sequence of f-plane experiments of increasing complexity. For an atmosphere of uniform PV with a rigid-lid tropopause both the semi-geostrophic and the primitive-equation frameworks yield similar results and confirm the forementioned influence of lateral shear. The inclusion of a more realistic tropopause leaves the main structural features at the surface unchanged, and permits the analysis of the relationship between upper-level potential vorticity structures and the surface development. Consideration is also given to the storm-track signal related to the two classes of idealized cyclone development, and to the possibility of includin g moist processes to the simulations.

ST21/OA9 Biogenic air-sea fluxes and processes in coastal and marginal seas

Convener: Buat-Menard, P.
Co-Convener: Owens, N.J.

THE GIRONDE ESTUARY : A MAJOR HETEROTROPHIC SYSTEM

G. Abril, P. Buat-Menard, J. Castel, H. Etcheber, J.C. Relexans (D.G.O., Université Bordeaux I, Avenue des Facultés, 33405 Talence, France)
M. Frankignoulle (Université de Liege, Mécanique des Fluides Géophysiques, Unité d'Océanographie Chimique, Institut de Physique (B5), B4000 Sart Tilman, Belgium)

The Gironde Estuary is a typical macro-tidal estuary of the European Atlantic zone, with pronounced influence of terrigenous organic inputs and long residence time of both water (3 months) and particles (18-24 months).The sedimentological budget of organic matter (evaluation of input-settling-output) reveals the disappearance of a huge amount of particulate organic carbon inside the estuary, whereas dissolved organic fraction behaves conservatively. The main part of the organic material which disappears in the estuary is from terrigenous origin: on the one hand, the estuarine primary production remains low whatever the season (light limitation effects due to high suspended matter content); on the other hand, the labile fraction of the fluvial organic matter is quite important. Mineralization processes within the estuary then appear predominant: settling and resuspension cycling of particulate material plays an important role in these mechanisms. The recent studies of CO2 distribution and related atmospheric exchange confirm the importance of mineralization processes. Interesting correlations between CO2 emissions and organic loads are expected when comparing the data obtained in different estuaries (Scheldt, Gironde and Rhine estuaries).

NATURAL AND ANTHROPOGENIC VOLATILE METAL AND METALLOID COMPOUNDS IN ESTUARINE ENVIRONMENTS

D. Amouroux , C. Pécheyran, H. Pinaly, C.M. Tseng and O.F.X. Donard. (Laboratoire de Chimie Bio-Inorganique et Environnement - EP CNRS 132, Université de Pau et des Pays de l'Adour, Hélioparc, 64000 Pau, France.)

The distribution of dissolved and atmospheric volatile compounds of trace metals and metalloids has been investigated along the Gironde, Scheldt and Rhine estuaries. An analytical method, involving cryogenic trapping, GC and ICP/MS allowed us to perform simultaneous determinations on several trace elements. Water and atmospheric samples were collected during 6 cruises on the Gironde, Scheldt and Rhine estuaries along with hydrological parameters. Significant results were obtained for Hg, Pb, Se and Sn. Volatile Hg was mainly found as elemental Hg in both phases. Potential natural and anthropogenic sources of Hg^0 in estuarine environments are then suggested. Volatile Pb was mainly detected in the atmosphere and under the molecular forms used in gasoline enrichment. Gaseous deposition of Pb in estuarine waters may also be established. Volatile selenium compounds in estuarine waters were found to be related to biological methylation processes and a large fraction of dissolved Se evades to the atmosphere. Volatile tin compounds have been discovered probably originating from both biomethylation processes and TBT release from antifouling paintings. Interactions in estuarine environments between anthropogenic inputs and biological activity lead to the formation of volatile metals and metalloids compounds. Gas phase exchanges of these elements seems to be significantly important to re-examine their coastal cycling.

DISTRIBUTION OF METHANE AND NITROUS OXIDE IN THE WESTERN ODER ESTUARY (SOUTHERN BALTIC SEA)

H.W. Bange, R. Ramesh, S. Rapsomanikis and M.O. Andreae (Max Planck Institute for Chemistry, Biogeochemistry Dept., P.O. Box 3060, 55020 Mainz, Germany)
S. Dahlke, L.-A. Meyer-Reil (Institute for Ecology, Ernst Moritz Arndt University Greifswald, Schwedenhagen 6, 18565 Kloster/Hiddensee, Germany)

Methane (CH_4) and nitrous oxide (N_2O) were measured as part of the German *GOAP* project at several sampling stations located in the various sub-basins of the estuarine system of the Oder river (southern Baltic Sea). Four cruises took place between 1994 and 1996. We determined atmospheric and dissolved N_2O and CH_4 by using a GC-ECD/FID system interfaced to a seawater-air equilibrator. The CH_4 saturation values showed a great seasonal and spatial variability and ranged from 300 to 16,000 %. Nitrous oxide saturations were near equilibrium with the atmosphere. Enhanced N_2O concentrations where only observed near discharges of nitrogen-rich waters. Air-sea flux estimates indicate that the investigated coastal waters play a significant role in the biogeochemical cycling of CH_4 and N_2O in the Baltic Sea ecosystem.

IN-SITU MEASUREMENT OF NITROUS OXIDE USING AN ELECTROCHEMICAL SENSOR

J. Barnes, A. Mellor. N.J.P. Owens (Dept Marine Sciences and Coastal Management, University of Newcastle upon Tyne, Newcastle upon Tyne, NE1 7RU)

A functional sensor designed for the in-situ determination of nitrous oxide is described. The technique uses dual polarisation to quantitatively reduce oxygen and nitrous oxide (N2O). The resulting measured current is proportional to ambient concentrations of the respective species. A specialised data acquisition programme has been developed to supply the required pulse trains with integrated signal capture. The inherent flexibility within this control system allows the utilisation of several types of electrode e.g. a micro-electrode for sediment work or a planar electrode for water column work. This system has recently been tested on a North Sea cruise.

NITROUS OXIDE IN ESTUARIES AND COASTAL WATERS

J.Barnes, N.J.P. Owens. (Dept. Marine Sciences and Coastal Management, University of Newcastle upon Tyne, Newcastle upon Tyne, NE1 7RU)

Three years worth of concentration data distributions for dissolved and atmospheric Nitrous oxide (N_2O) in the North Sea and two East UK estuaries, the Humber and Tweed, are presented. Highest N_2O values were recorded in the low salinity zone (0-2) of the Humber, a well mixed macro estuary, where typical saturations exceed 2000%, relative to ambient air, with maxima over 10000%. This region is a site of active N_2O production throughout the year. Principal production mechanisms are nitrification/denitrification. Seaward of this N_2O production zone , N_2O shows quasi-conservative behaviour. In contrast the Tweed, an unmixed estuary with a residence time of less than two tidal cycles, shows N_2O values close to atmospheric saturation (96-110%) at all sites investigated. Coastal areas exhibited near equilibrium to slight supersaturations (98-125%) with highest levels adjacent to riverine inputs.

MACRO-SCALE VARIATIONS OF pCO_2 DISTRIBUTION ALONG THE BELGIAN COAST

A.V. Borges. M. Frankignoulle (Université de Liège, Mécanique des Fluides Géophysiques, Unité d'Océanographie Chimique, Institut de Physique (B5), B4000 Sart Tilman, Belgium)

The macro-scale variations of partial pressure of CO_2 (pCO_2) and related parameters (pH, oxygen, total alkalinity, chlorophyll a and phaeopigments concentrations) were measured in surface water, along the belgium coast, from January 1996 to July 1996, using a fully automated pCO_2 equilibrator. The pCO_2 distribution is dominated by the river input from the Scheldt, that is known to carry highly CO_2-rich water. In Winter, the river Scheldt plume is over-saturated in CO_2 with respect to the atmosphere (around 155%); in Spring and early Summer, important photosynthetic activity, due to the eutrophication, induces under-saturation of CO_2 near the river mouth (ranging from 70% to 90%). Furthermore, the degradation of phytoplanctonic cells, transported by the residual current, induces the over-saturation in the farthest area of the plume. Thus, from one season to another, the river plume acts either as a source or a sink of atmospheric CO_2. On another hand, for all the campaigns, the water outside the river Scheldt plume (Channel water) was under-saturated in CO_2. Further research is needed to determine whether this area acts globally as a source or a sink of atmospheric CO_2.

BIOGAS TRANSFER IN ESTUARIES (BIOGEST')

M. Frankignoulle (Université de Liège, Mécanique des Fluides Géophysiques, Unité d'Océanographie Chimique, Institut de Physique (B5), B4000 Sart Tilman, Belgium)

Estuaries are extremely dynamic systems usually characterized by strong physico-chemical gradients, enhanced biological activity and intense sedimentation and resuspension. Estuaries are also subject to intense anthropogenic disturbance such as loadings of detrital organic matter, nutrients and toxic trace elements. All these features increase the potential for biogenic gas production within estuaries. In spite of their potential importance, very little is known about estuaries and their atmospheric coupling. The four objectives of the BIOGEST project are 1) to determine the distribution of biogases affecting climate and atmospheric chemistry in surface water of nine European estuaries, 2) to evaluate the atmospheric biogases fluxes in European estuaries and their impact on the global budget, 3) to understand major biological processes which are responsible for biogases distribution, 4) to develop a predictive biogeochemical model which can be used to relate biogases emission to organic matter and nutrients loadings.
BIOGEST is an EU funded project within ELOISE programme, including 12 European institutions. A general overview of the project is presented.

AIR-SEA CO_2 FLUXES AND COMMUNITY METABOLISM IN CORAL REEFS

J.-P. Gattuso (Observatoire Océanologique Européen, Avenue Saint-Martin, MC-98000 Monaco)
M. Pichon, B. Delesalle (EPHE, URA 1453 CNRS, 66860 Perpignan, France)
M. Frankignoulle (FNRS, Université de Liège, Belgium)

Community metabolism was measured on two barrier reef flats at Moorea (French Polynesia) and Yonge reef (Great Barrier Reef). Gross primary production (P_g) and respiration (R) ranged between 642-1275 and 642-1250 mmol CO_2 m^{-2} d^{-1}, respectively. Both sites displayed a low net primary production. Net calcification (G) ranged from 186 to 253 mmol $CaCO_3$ m^{-2} d^{-1}.
Field measurements of the CO_2 partial pressure (pCO_2) and air-sea CO_2 fluxes showed that both reef flats were sources of CO_2 for the atmosphere (1.8-5.1 mmol CO_2 m^{-2} d^{-1}) because the CO_2 released by calcification was higher than net photosynthetic uptake of CO_2.
Additional measurements carried out on a fringing reef at Moorea showed that an algal-dominated reef flat can behave as a sink for CO_2 (-10 mmol CO_2 m^{-2} d^{-1}) due to the overriding effect of net photosynthesis on net calcification.
The effect of coral reefs on atmospheric CO_2 will be discussed on a global scale.

The importance of aerobic and anaerobic methane oxidation in regulating methane emission from coastal marine areas.

Niels Iversen (Environmental Engineering Laboratory, Sohngaardsholmsvej 57, DK-9000 Aalborg, Denmark)

Methane emission from coastal marine areas is to a large extent regulated by methane oxidation. Anaerobic methane oxidation is quantitatively the most important sink which removes more than 90% of the methane produced in the sediment. The residual methane is still sufficient to generate a large potential sediment water methane flux ranging from 0.008 to 3.1 mmol $m^{-2}d^{-1}$ in Danish coastal areas. A significant part of the potential methane flux is removed by aerobic methane oxidation at the sediment surface. Aerobic methane oxidation rates up to 1mmol $m^{-2}d^{-1}$ have been observed in Danish coastal sediments and on average 50% of the potential methane flux are oxidized at the sediment surface. A minor part of the methane escaping the sediment is oxidized by aerobic methane oxidation in the water column. In total, methane oxidation accounts for a nearly complete removal of the methane produced in these sediments, and only a very minor fraction actually escapes to the atmosphere

NATURAL GAS SEEPS AS SOURCES OF ATMOSPHERIC METHANE: CONTRIBUTIONS FROM EUROPEAN SEAS.

A.G Judd (Centre for Marine & Atmospheric Research, School of the Environment, University of Sunderland, Benedict Building, St Georges Way, Sunderland, SR2 7BW, UK)

Natural gas seeps and accumulations of gas in sediments close to the seabed are common features on the continental shelves. The gas is principally methane.
Shallow gas accumulations may be indicated by acoustic turbidity on shallow seismic reflection profiles. On high frequency seismic systems (e.g. echo sounders and 3 5kHz profilers) seeps may be represented by a water column target, however this is dependent upon the resonant frequency, and therefore the size, of the gas bubbles. There may also be confusion between targets presented by fish shoals and seepage plumes, but the former tend to be random in shape and / or horizontally elongate, whereas the latter are vertically elongate
An indication of the distribution of shallow gas and gas seeps on the European continental shelves is obtained from a review of public-domain seismic profiles (UK waters) and published data (other European waters). This review suggests that seabed gas is widespread, and that gas seeps make a significant contribution to methane concentrations in the water column. Furthermore, modelling suggests that (depending upon bubble size and water depth) a proportion of gas bubbles emitted from the seabed will survive passage through the water column to contribute to atmospheric methane levels. Preliminary estimates suggest that this contribution is comparable to that of other (terrestrial) sources of atmospheric methane.

AIR–SEA EXCHANGE OF CO_2, DIFFERENT ESTIMATION TECHNIQUES.

Joergen F. Kjeld and Soeren E. Larsen (Wind Energy and Atmospheric Physics Department, Risoe, Denmark)

Air–Sea exchange is usually estimated by the exchange coefficient method and employing the difference in pCO_2 between air and water, measured in specific depth and height.
The validity of this method for inhomogeneous and instationary situations is studied by using a model which solves the numerical diffusion/conservation equation by Fouriertransforming the horizontal variation of the concentration in CO_2. The model takes into account that the carbon content in the water is buffered, that the wind field is instationary, and that heat– and water vapour fluxes can vary with space and time.
Estimation of the fluxes are found in different cases. From the simple case where only the concentration distribution of CO_2 in the water is allowed to vary, to the case where also the instationarity of the wind field, the buffer mechanism in the water and the fluxes of heat– and water vapour fluxes are included. These different cases are compared to see what effects these included mechanism will have on the exchange of CO_2, and it has shown up, that the surface fluxes in instationary and inhomogeneous cases can vary in order of magnitudes compared to the results from the exchange coefficient methods. The output of the model is also compared with resently achieved data from European measurement programs.

Implications of Methane Concentration and Oxidation Rates from a Partially Mixed Estuary on the Atmospheric and Coastal Systems

S.M.Starr, N.J.P. Owens (Department of Marine Sciences, University of Newcastle, Newcastle upon Tyne, NE1 7RU, UK)
J.C.Murrell (Department of Biological Sciences, University of Warwick, Coventry, CV4 7AL, UK)

Methane is an important greenhouse gas whose mixing ratio in the atmosphere is currently around 1.74 ppmv, and is increasing at approximately 1% a year. In some oceanic environments it has been found to be in equilibrium with respect to the atmosphere while others exhibit typical supersaturations in the order of 130%. Some estuaries have been found to be a major source of methane to the global troposphere and coastal areas. In this paper we describe a 12 month field study of methane concentrations and oxidation rates in the Tyne estuary, in the NE of England. Results show that methane levels were spectacularly high with levels of up to 30000% supersaturation and concentrations ranging from 15 to 1500 nmol l^{-1} with the highest saturations and concentrations found in the lower salinity region of the estuary. Methane oxidation rates, were also found to vary extensively ranging from 0.8pmol $l^{-1}.d^{-1}$ to 195 nmol $l^{-1}.d^{-1}$, with methane concentration being a major controlling factor. These observations will be used to discuss the possible effect of the Tyne estuary to both the atmosphere and local coastal systems.

CHANGES IN THE REDFIELD-RATIOS IN THE ARABIAN SEA

J. Karstensen (Institut für Meereskunde der Universität Hamburg, Troplowitzstr. 7, 22529 Hamburg, Germany)
A. Hupe (Institut für Biogeochemie der Universität Hamburg, Bundesstr. 55, 20146 Hamburg, Germany)
J. van Bennekom (NIOZ, P.O.Box 59, 1790 Ab Den Burg, Texel, The Netherlands)

The biogeochemical cycling in the Arabian Sea is strongly influenced by the seasonal wind-driven up- and downwelling along the Arabian coasts and in the open ocean as well as by the oxidation of nitrate in the oxygen minimum layer north of about 12° N. Based on hydrographic data collected during the METEOR 32 cruises during summer 1995 we investigated the local modifications of the traditional Redfield-Ratio tracers: oxygen, carbon, phosphate and nitrate by applying an OMP water mass mixing model. The classical OMP analysis is expanded by including biogeochemical changes. The mixing of water masses is quantified and compared with results from CFM analysis. The Redfield-Ratios of the Arabian Sea are mapped.

THE FORMATION OF LIGHT HYDROCARBONS IN SEA WATER: MECHANISMS AND CONSEQUENCES FOR BIOLOGICALLY ACTIVE REGIONS

J. Rudolph, M. Ratte, O. Bujok and Ch. Plass-Dülmer (Institut für Atmosphärische Chemie, Forschungszentrum Jülich, D-52425 Jülich, Germany)

Since several years it is established that ocean surface waters are generally supersaturated with respect to many light hydrocarbons. Thus sea water acts as a source for atmospheric light hydrocarbons. In a number of field and laboratory investigations we studied the concentrations of light hydrocarbons in the surface water of the ocean, the mechanisms responsible for the formation of light hydrocarbons in ocean water and the factors determining the hydrocarbon fluxes between ocean and atmosphere.
In ocean surface waters the most abundant hydrocarbons are light alkenes, especially ethene and propene. Consequently these compounds also have the highest emission rates. Emission into the atmosphere seems to be the dominant loss process for light alkenes from the surface waters of the ocean. Thus emission rates into the atmosphere can, as a first aproximation, be estimated from the oceanic production rates.
The main source of light alkenes in the ocean is photochemical production from dissolved organic carbon (DOC). The production rates depend on the concentration of dissolved organic carbon (DOC) and the irradiation intensity with UV and short wavelength visible light.
Thus it can be expected that marginal seas with high DOC concentrations are substantial sources of light alkenes. However, it should be noted that the penetration depth of light into the ocean will play a key role in the total, column integrated alkene production in the ocean. Since the extinction of light in sea water and the DOC concentration are to some extent correlated, the column integrated alkene production in active coastal zones is not strictly proportional to the DOC concentrations.

Carbonyl sulfide photoproduction rates in relation to chromophoric dissolved organic matter distribution in surface seawater

G. Uher (Univ. Newcastle, Dept. Mar. Sciences & Coastal Management, Ridley Building, Newcastle upon Tyne NE1 7RU, U.K.)
M. O. Andreae (Max Planck Institute for Chemistry, Biogeochemistry Department, P.O.Box 3060, D-55020 Mainz, Germany)

Carbonyl sulfide (COS) photoproduction rates in North Sea water were determined on samples collected inshore and offshore the island of Helgoland during April 1993. A simple kinetic model including a zeroth order photoproduction constant, surface UV light intensity, and hydrolysis removal satisfactorily describes our results. The mean COS production constants were (2.8 =B1 0.5) fmol liter-1 s-1 W-1 m2 at the inshore station and (1.2 =B1 0.3) fmol liter-1 s-1 W-1 m2 at the offshore station, corresponding to sea surface COS production rates of 0.84 nmol liter-1 d-1 and 0.38 nmol liter-1 d-1 for the inshore and offshore station, respectively. The photoproduction constants normalized to UV absorbance at 350 nm and fluorescence intensity of humic substances were similar for the two sampling stations, indicating that the COS formation is closely related to the concentration of chromophoric dissolved organic matter (CDOM) in seawater. The COS photoproduction rates from this work and a compilation of presently available data show a remarkably high degree of correlation with CDOM absorbance. We propose that the geographical distribution of COS productivity may be extrapolated from remotely sensed CDOM optical properties.

SEA-AIR GAS TRANSFER VELOCITIES IN THE SOUTHERN NORTH SEA MEASURED WITH VOLATILE AND CONSERVATIVE TRACERS : FIRST RESULTS FROM THE ASGAMAGE EXPERIMENT, OCT. 1996.

R.C. Upstill-Goddard (Department of Marine Sciences and Coastal Management, University of Newcastle Upon Tyne, NE1 7RU, U.K.)
P.D Nightingale (Plymouth Marine Laboratory, Plymouth PL1 3DH, U.K). and
G. Malin, School of Environmental Sciences, UEA, Norwich NR4 7TJ, U.K.).

During the 1996 "ASGAMAGE" experiment in the S.E. North Sea, gas transfer velocities were determined approximately twelve-hourly over a ten day period, both with the SF_6 / ^3He "dual tracer technique" and individually for SF_6 and ^3He, with corrections for dispersive dilution made with rhodamines WT and G and inert spores of *Bacillus globigii*.. 8 x 10^{14} spores were added to 2250 dm^3 of seawater in a sealed steel tank, with SF_6 and ^3He subsequently added by bubbling. Rhodamines were dissolved separately in 1000 dm^3 of seawater. A five hour, coordinated tracer release into shallow, tidally well mixed waters ~ 20 km off the Dutch coast produced a "tracer patch" ~8 km long, which was labelled with drogued Argos satellite buoys. Continuous underway measurements of SF_6 were used to locate the patch centre, which was sampled routinely for the complete suite of tracers every twelve hours. Windspeed was also monitored continuously. The results allow for the first time, the direct comparison of gas transfer velocities determined at a range of windspeeds with three different combinations of tracers.

Influence of enhanced biological activity on air-water CO_2 exchange in the Scheldt estuary

R. Wollast and M. Loijens (Université de Bruxelles, Belgium)
M. Frankignoulle and Ch. Canon (Université de Liège, Belgium)

It is well known that estuaries are characterized by enhanced biological activity usually due to the presence of high levels of detrital riverine organic matter and nutrients. This is especially true in macro-tidal estuaries where long residence times of water masses can be observed and which are on the other hand often submitted to strong anthropogenic perturbations. This is the case for the Scheldt estuary where we have performed simultaneous measurements of primary production, bacterial respiration and atmospheric exchanges of CO_2. These measurements were carried out over the entire estuary and repeated under various seasonal conditions. Due to the high organic matter load, the upper part of the estuary is dominated all over the year by intensive bacterial respiration, producing anoxic conditions in the water column and pCO_2 levels which may exceed 8000 ppm. This contrasts with the situation at the mouth of the estuary, where the low turbidity and relatively high nutrient content of the water masses intensifies the primary production. Furthermore, the reactive organic matter concentration is reduced to a low level and the bacterial respiration is thus limited near the mouth. The net effect is that during spring and summer, pCO_2 may reach values as low as 100 ppm and thus the mouth of the estuary and the adjacent coastal zone are acting as a sink for atmospheric CO_2.

BREAKING WAVES AND AIR-SEA GAS TRANSFER; THE LUMINY PROJECT.

D K Woolf, Southampton Oceanography Centre, UK, S E Larsen, Riso, Denmark. G de Leeuw,TNO FEL,The Netherlands. G Caulliez,Institut de Recherches sur les Phenomenes Hors Equilibre, France. P A Bowyer, University College Galway, Ireland. P D Nightingale, Plymouth Marine Laboratory, UK. S Rapsomanikis, Max Planck Institut fur Chemie Mainz, Germany

The air-sea transfer velocities of gases are only known approximately. Breaking waves are a major but poorly understood factor, but enhance the air- sea exchange of poorly soluble gases by at least three mechanisms: 1) Transfer associated through turbulence generated by breaking waves. 2) Transfer, while gas is within bubbles in the ocean. 3) Transfer across the sea surface when the microlayer has been disrupted by bubbles bursting. These mechanisms are investigated in experiments in the large air-sea interaction simulation tunnel of IRPHE-IOA (Luminy, France) using combinations of aeration devices, mechanical wave generation and wind. A number of gases with widely varying solubilities and molecular diffusion constants have been measured in order to investigate the functional dependence of the transfer velocity. A large number of physical parameters are measured including wind stress, wave characteristics, whitecap coverage and bubble fluxes. The experiments with aeration devices have demonstrated the remarkable efficiency of bubble-mediated transfer (particularly for the least soluble gases) and the ability of bubbles to force the supersaturation of dissolved gases. The experiments with wind and mechanical wave generation have demonstrated the sensitivity of wave breaking to "sea state" at a fixed wind speed. The experiment has elucidated the role of breaking waves in air-sea gas exchange. Once it is recognised that gas transfer velocities are sea state dependent, and this applies both to simulation facilities and the real world, it is necessary to seek practical parameters for predicting transfer in addition to the wind speed or stress. Thus, we must relate gas transfer coefficients to whitecap coverage, bubble statistics or energy dissipation.

MODELING OF THE ANOXIC CONDITIONS FORMATION AND ESTIMATING OF THE DENITRIFICATION RATE AS AN EXAMPLE OF THE BLACK SEA

Evgeniy V. Yakushev, Shirshov Institute of Oceanology, 23 Krasikova St., Moscow 117218 Russia

The investigations of anoxic conditions in natural waters appears to be very significant because they can be formed both by as natural and anthropogenic ways, as a result of local ecological catastrophes. The one-dimensional model describing nitrogen, manganese and sulfur cycles in suboxic and anoxic conditions is considered. The modeled vertical distributions of nitrogen compounds (total organic nitrogen, ammonium, nitrate, nitrite), dissolved and particulate manganese and inorganic reduced sulfur compounds (hydrogen sulfide, elemental sulfur, thiosulfate, sulfate) as well as dissolved oxygen are adequately corresponded to the observed situation. The model takes into account the processes of turbulent diffusion, sedimentation and biogeochemical transformation of compounds. On the base of the model it was demonstrated, that the anoxic and suboxic conditions form because of organic matter mineralization in condition of restricted oxygen influx. The vertical distribution of rates of sulfur and nitrogen cycles processes were calculated within the frames of the model. According to model the total amount of gaseous nitrogen formation connected with denitrification equals 1 Tg N/yr for all the Black Sea. The model rate of this processes 0.3 mmol/day per square meter can be typical for the regions, where anoxic conditions take place.

OXYGEN DEPLETION IN THE NORTH SEA - AN ANALYSIS OF HISTORICAL OXYGEN DATA

C. Young and N.J.P.Owens
(Dept. Marine Sciences and Coastal Management, University of Newcastle upon Tyne, Newcastle upon Tyne, NE1 7RU)

An extensive analysis of historical oxygen concentration data from the North Sea, spanning the period 1902-1994, was carried out. The data identified areas exhibiting depleted bottom water oxygen concentrations during the late summer, often below ecologically critical levels, some of which were not normally associated with low oxygen events. The data for these regions were subjected to further analysis and the occurrence and severity of oxygen depletion events was shown to differ over a range of spatial and temporal scales through the 92 year period. Results are discussed in relation to hydrography and trends in eutrophication.

ST22/0A10 Sulphur cycle in the marine atmosphere

Convener: Suhre, K.
Co-Convener: Berresheim, H.

TRANSPORT AND OXIDATION OF DIMETHYLSULFIDE OVER ANTARCTICA - RESULTS FROM PROJECT SCATE

H. Berresheim (Deutscher Wetterdienst/MOHp, Albin-Schwaiger-Weg 10, 82383 Hohenpeissenberg, Germany)
F.L. Eisele, D.J. Tanner, and A. Jefferson (National Center for Atmospheric Research/ACD, Boulder, CO 80307, USA)
D.D. Davis and G. Chen (Georgia Inst. of Technology, School of Earth and Atmospheric Sciences, Atlanta, GA 30332, USA)

Results from the Sulfur Chemistry in the Antarctic Troposphere Experiment (SCATE) conducted in 1994 suggest the following conclusions: 1. The transport and distribution of DMS over Antarctica is promoted by intense mesoscale storm systems and a relatively long tropospheric DMS lifetime (about 12 days). 2. A significant fraction of DMS may be converted to DMSO and $DMSO_2$ in the Antarctic free troposphere. 3. Measurements of these products and meteorological analyses suggest a sporadic downward mixing of free tropospheric air into the boundary layer. 4. Both DMS products are removed mainly by physical losses. 5. Model calculations suggest that SO_2 was not the major source for observed H_2SO_4 levels.

SULFUR CHEMISTRY OVER THE PACIFIC AND SOUTHERN OCEANS

W J De Bruyn and E S Saltzman (At: Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, Miami, FL 33149)
T Bates (NOAA/PMEL, 7600 Sandpoint Way NE, Seattle,WA 98115)

Real time measurements of sulfur dioxide were made on board the R/V Discoverer during a transect from Seattle to Hobart, Tasmania and in the Southern Ocean as part of the first IGAC Aerosol Characterization Experiment. Background SO_2 levels increased from 10 ppt at 20°N, to a maximum of 100 ppt at the Equator, then decreased again to 10 ppt in the Southern Ocean. A comparison of background SO_2 with simultaneously measured DMS concentrations shows evidence of anticorrelated diurnal variations at both the equator and in the Southern Ocean. DMS/SO_2 ratios increase dramatically with latitude indicating much higher DMS to SO_2 conversion efficiencies at the equator. The data are examined using simple steady state and photochemical box models and the implications for DMS oxidation chemistry are discussed.

HIGH MSA/NSSSO$_4$ VALUES IN THE ATMOSPHERE AND SNOW AT POLAR LATITUDES: A TENTATIVE EXPLANATION

R. J. Delmas
Laboratoire de Glaciologie et Géophysique de l'Environnement du CNRS
BP 96, 38402 St Martin d'Hères-Cedex, France

DMS oxidation into MSA and SO_2 occurs rapidly in the atmosphere. The further transformation of SO_2 into $nssSO_4$ may occur either in the gaseous or in the liquid (cloud water) phase, the latter process being considered generally as overwhelming on a global scale. The ratio (R= $MSA/nssSO_4$) between the mass concentrations of $nssSO_4$ and MSA varies progressively from about 0.05 at low latitudes up to more than one in sub-Antarctic regions (aerosol and snow measurements). It is commonly put forward that this effect is due to a temperature dependance of the branching ratio of the DMS oxidation process, the formation of MSA being favoured by low temperatures. We propose a mechanism leading to the formation of an "additional" natural source of background sulfate, which would be, in fact, also derived from marine DMS and essentially linked to the extremely cold Antarctic conditions. Our proposal, based on the partial decoupling of the MSA and $nssSO_4$ atmospheric cycles at high latitudes, would explain the high R values observed in these regions close to DMS source regions, without excluding the temperature dependance of R found at lower latitudes. The phenomenon should also occur in the Arctic.

Uncertainties of DMS concentrations calculated by a global atmospheric circulation-chemistry model

Johann Feichter, Max-Planck-Institute for Meteorology, Hamburg, Germany

The Hamburg general circulation model ECHAM coupled to a sulfur chemistry model is used to calculate the distribution of the main atmospheric sulfur compounds. Marine sources of DMS are derived from observed sea-water DMS concentrations applying the approach by Liss and Merlivat to calculate the air-sea gas exchange. Resulting atmospheric concentrations of DMS, SO2 and sulfate are compared to observations. Based on this comparison uncertainties of the source strength and distribution and of the the oxidation pathways are discussed. Additionally, the contribution of marine DMS emissions to the global sulfate burden is estimated.

FLUX OF DMS IN MEDITERRANEAN COASTAL ZONE AND CORRELATION WITH SEA STATE AND FINE PARTICLES.

J. Gourdeau, S. Despiau, O. Le Calvé
Laboratoire d'Echanges Particulaires aux Interfaces, BP 132, 83957 La Garde Cedex, France.

DMS is transferred at the sea-air interface and then transformed into particles by gas-particle conversion. It is believed to be the major source of sulphate aerosols in the non-polluted marine atmosphere. These aerosol particles act as cloud condensation nuclei and play an important role in the climate-cloud hypothesis. DMS concentration in the seawater is much greater than in the air, and the transfer velocity depends on molecular diffusivity, wind speed and thermal stability at the sea surface. The presence of whitecaps at the interface considerably enhances the transfer, because they break the laminar surface layer and, when they burst at the surface, each whitecapp air bubble may also transfer gas exchanged in subsurface between water and air bubble. So, the surface sea state must be taken into account to better know the flux of DMS from ocean to atmosphere. Often, coastal zone represents specific cases of sea state, thermal instability and biogenic production of DMS. To study this specificity, DMS concentrations in the coastal zone located off Toulon-Hyères are measured by the cryotrapping-Gas Chromatography-Flame Photometric Detector method. The interpretation of our data is focused on the whitecap cover influence. We use photo and video image processing to quantify whitecap cover area with respect to the meteorological conditions, and try to relate it to the DMS concentration. We present here the first results of both DMS / sea state measurements.

DMS OXIDATION IN THE ANTARCTIC MARINE BOUNDARY LAYER

A. Jefferson, F.L. Eisele, and D.J. Tanner, (National Center for Atmospheric Research/ACD, Boulder, CO 80307, USA)
D.D. Davis (Georgia Inst. of Technology, School of Earth and Atmospheric Sciences, Atlanta, GA 30332, USA)
H. Berresheim (Deutscher Wetterdienst/MOHp, Albin-Schwaiger-Weg 10, 82383 Hohenpeissenberg, Germany)

Dimethylsulfide (DMS) is thought to be the most important precursor of sulfur oxides and sulfate particles in the Antarctic troposphere. A major objective of the field campaign SCATE conducted in 1994 at Palmer Station, Antarctica, was to clarify those factors controlling atmospheric DMS oxidation by measuring the concentrations of the species DMS, OH, DMSO, $DMSO_2$, H_2SO_4, MSA, NO, O_3, H_2O, and particle number and density. Some interesting case studies are presented here. DMS oxidation in the Antarctic coastal boundary layer was found at times to yield as much MSA as H_2SO_4. Residence times of gas phase MSA and H_2SO_4 were estimated to be less than 2 hours. $DMSO_2$ may not be a major oxidation product of DMSO.

OXIDATION MECHANISM OF DIMETHYL SULFIDE IN THE ATMOSPHERE : STATUS OF THE KNOWLEDGE

G. Le Bras (Laboratoire de Combustion et Systèmes Réactifs, CNRS, 45071 Orléans cedex 2, France)

The oxidation mechanism of dimethyl sulfide (DMS) determines the end product distribution, i.e. SO_2, SO_3 and CH_3SO_3H (methanesulfonic acid, MSA) and, hence, the MSA/SO_4^{2-} ratio, which is crucial for an accurate assessment of the climatic impact of DMS. Laboratory studies have recently provided a lot of kinetic and mechanistic data on the simple steps involved in this mechanism as well as mechanistic information on the overall mechanism. In our laboratory, for instance, data have been obtained recently for the initial oxidation steps of DMS by NO_3, Cl and BrO radicals, and for reactions of the CH_3SO_2 intermediate species (Butkovskaya and Le Bras, J. Phys. Chem. 1994, 98, 2582-2591 ; Butkovskaya et al., J. Phys. Chem. 1995, 99, 4536-4543 ; Bedjanian et al., Int. J. Chem. Kinetics 1996, 28, 383-389 ; Ray et al., J. Phys. Chem. 1996, 100, 8895-8900). Based on these results and those recently published by other groups, it is proposed to present a status of the knowledge, with emphasis on the key steps which influence the end products distribution of the atmospheric oxidation of DMS.

PRELIMINARY RESULTS FOR YEAR-ROUND TROPOSPHERIC SO_2 CONCENTRATIONS OBTAINED FROM LOW VOLUME FILTER SAMPLING AT NEUMAYER STATION, ANTARCTICA

A. Minikin, A. Ebbeler, C. Kleefeld, O. Schrems (Alfred Wegener Institute for Polar and Marine Research, Postfach 120161, D–27515 Bremerhaven, Germany) and
D. Wagenbach (Institut für Umweltphysik, Universität Heidelberg, Im Neuenheimer Feld 366, D–69120 Heidelberg, Germany)

SO_2 is an important intermediate compound in the oxidation chain of biogenic dimethyl sulfide (DMS) with particulate sulfate as the stable end product. In the Antarctic troposphere the aerosol chemistry is characterized by a very distinct seasonal cycle of non-sea-salt sulfate and methanesulfonic acid (MSA), the latter being the only other relevant stable oxidation product of DMS. Since both components are reflecting the DMS emission of a vast area of the Southern Polar Ocean, chemical studies of Antarctic ice cores intend to reveal the long-term changes of the marine productivity. However, the relationship of MSA and non-sea-salt sulfate concentrations is not yet fully understood. SO_2 may play an important role, particularly during transport, as a relatively stable precursor of non-sea-salt sulfate, but not of MSA. Therefore, we started in 1996 a filter sampling program for SO_2 at the air chemistry observatory of Neumayer Station (70°S, 8°W) with the aim of obtaining year-round SO_2 concentrations for the (coastal) Antarctic troposphere. In this contribution, we will discuss the sensitivity of the method and compare the first results with the aerosol chemical composition and DMS concentrations at Neumayer Station.

EIGHT MONTHS OF DIMETHYLSULFIDE OBSERVATIONS AT NEUMAYER STATION, ANTARCTICA

Ch. Kleefeld and O. Schrems (Alfred-Wegener-Institute for Polar and Marine Research, Am Handelshafen 12, D-27570 Bremerhaven, Germany)

Longterm observations of the aerosol composition in the Antarctic troposphere show a pronounced seasonal cycle of non-sea-salt sulfate and methanesulfonate (MSA). These compounds are produced by the atmospheric oxidation of gaseous dimethylsulfide (DMS). In this contribution we present a record of DMS mixing ratios from a coastal Antarctic site, Neumayer Station (70°S, 8°W), covering a time period of 8 months. Daily measurements of atmospheric DMS started in June 1992 during the polar night and were conducted until February 1993. The DMS mixing ratios range from 0.5 to 75 pptv. The lowest concentrations are found during the period from August to November with an average mixing ratio of 1.0 pptv. In contrast to non-sea-salt sulfate and MSA, the DMS concentrations during the winter months June and July are relatively high and decrease exponentially from 65 pptv to a level of 1.0 pptv in August. The DMS increase was observed in December, which was about 2 months later than the increase of the aerosol species. In January DMS maxima of 75 pptv have been reached. The data suggest an accumulation of DMS in the atmosphere during autumn due to high DMS lifetimes. We assume that this atmospheric reservoir of DMS is the cause for the increase of the non-sea-salt sulfate and MSA concentrations in September. Following the retreat of the sea ice in summer, the importance of local DMS sources increases significantly. A contribution of additional DMS-oxidants apart from the OH-radical, which can explain the exponential decrease of the DMS mixing ratios during the polar night will be discussed.

DMS, Aerosols, and Climate: An Update

Meinrat O. Andreae

In their 1987 paper, Charlson, Lovelock, Andreae, and Warren (CLAW) proposed a link between the marine biota, atmospheric chemistry, and global climate. Sulfate reduction by marine micro-organisms results, directly or indirectly, in the formation of volatile sulfur species, the most important of which is dimethyl sulfide (DMS). These volatile compounds escape into the atmosphere, where they are the major natural inputs of sulfur. Atmospheric oxidation reactions result in the formation of sulfate aerosol (and some other oxidized sulfur species), which accounts for most of the sub-micron sized atmospheric aerosol particles and thus most of the cloud condensation nuclei (CCN) in the natural atmosphere. As a consequence, the emission of DMS from the oceans and the resulting modification of cloud optical properties through the production of cloud condensation nuclei was proposed to be a major control on global climate. In spite of intensive study over the last decade, many uncertainties about the CLAW hypothesis remain. The ecological and physiological variables which determine DMS concentrations in the surface ocean, the rate of transfer across the air-sea interface, the mechanisms and sites of new particle production from gaseous sulfur species, as well as the parameters which regulate CCN number concentrations in the atmosphere are still rather uncertain. Progress in this area of research over the last few years will be reviewed and critical problems will be discussed.

A CRITICAL ASSESSMENT OF THE CONVERSION RATIO OF SULFUR DIOXIDE TO SULFAT AEROSOL

D. Möller (Brandenburg Technical University, D-03013 Cottbus, P.O.Box 10 13 44, Germany)

In global and regional climate models calculating the sulfat aerosol forcing, a S(IV) to S(VI) conversion of 0.5 has been assumed. The aim of this paper is to show that (a) this conversion rate α is always smaller than 0.5 and (b) that α depends from many factors, which must be included in models decribing the sulfat budget.
It is known from many chemical transformation models which include heterogeneous processes that the S(IV) aqueous phase oxidation within clouds contributes $\geq 90\%$ to the total SO_2 oxidation. Möller and Mauersberger (1992) calculate that the importance of different sulfate formation pathways is dependent on daytime and season, and they suggest that the aqueous phase oxidation is always dominant. For annual averages, however, it is necessary to consider the frequency and duration of clouds (precipitation is negligible in terms of S(IV) oxidation) and the volume of the atmosphere occupied by them. Based on continuous cloud chemistry measurements at Mt. Brocken cloud data which are typical for middle Europe will be presented.
Another important question concerns the function of SO_2 that is dry-deposited because this amount of sulfur is not available to be transformed into sulfate within the atmosphere. A significant share of S(VI) produced in clouds remains on a time average as solute in droplets. Putting all information on S(IV) to S(VI) transformation and the reservoir distribution together we conclude that $\alpha \approx 0.3$.

SOURCES OF AEROSOL NITRATE AND NON-SEA-SALT SULFATE OVER THE EASTERN MEDITERRANEAN

Turkan Ozsoy, A. Cemal Saydam, Nilgun Kubilay, Oya B. Nalcaci and Ilkay Salihoglu

Daily aerosol filter samples collected on the South-Eastern Mediterranean coast of Turkey (360 33'54" N and 34o 15' 18" E) during the October-1991 - December 1992 period were anayzed to determine concentrations for thirteen trace metals and the Cl-, NO3- and SO4= ions. Chemical compositions of these samples along with three dimensional airmass back trajectory analyses revealed that the basin is under the influence of sporadic dust events mainly originated from Sahara. nss-SO4= and NO3- concentrations were relatively low during winter months. The highest nss-SO4= concentrations (20.0 Ug/m3) were measured in spring and early summer months (April-July). The coincidence of highest nss-SO4= concentrations with the periods following high levels of mineral dust suggests that the biogenic DMS was the dominant source of aerosol nss-SO4= in this region.

AEROSOL COMPOSITION IN THE MARINE BOUNDARY LAYER AND THE FREE TROPOSPHERE AT TENERIFE (28°N, 16°W)

J.P. Putaud, Rita van Dingenen, Monica Mangoni, Aki Virkkula and Frank Raes (European Commission, Joint Research Centre, I-21020 Ispra (VA), Italy)

Aerosol has been sampled using 2 stacked filter packs with a 1.4 µm aerodynamic cut-off at one site in the marine boundary layer (MBL) and one site in the free troposphere (FT) on Tenerife island during July 1996. The samples have been analysed for organic acids, principal anions, and principal cations by ion chromatography. The fine fraction has also been analysed for organic carbon (OC) and black carbon (BC) using a thermal technique. Submicron particle size distributions were measured using differential mobility particle sizers (DMPS). In the MBL (60 m a.s.l.) the coarse fraction was always dominated by sea salt, though non sea salt (nss) Ca^{2+} was observed in most of the samples. The fine fraction was dominated by $nssSO_4$ and associated components, as indicated by the correlation between submicron particle volume and $nssSO_4$ concentration in the fine fraction. However, $nssSO_4$ accounted for only 24% to 52% of the mass during cleaner and polluted periods, respectively. OC and BC contributed for 11-22% and 2-7% to the fine fraction aerosol mass, respectively. In the FT (2360 m a.s.l.), the coarse fraction was always dominated by mineral dust. Preliminary results indicate that even during clean conditions insoluble particles could have been a major component of the aerosol fine fraction as well. Inorganic species (mainly SO_4+NO_3+NH_4) and carboneous species (OC+BC) contributed for comparable amounts to the aerosol fine fraction mass.

MESOSCALE MODELLING OF DMS DURING ACE-1 LAGRANGIAN #B

K. Suhre, C. Mari, R. Rosset (Laboratoire d'Aérologie, UMR CNRS/UPS 5560, 14, avenue Edouard Belin, 31400 Toulouse, France)
T. Bates, J. Johnson (NOAA/PMEL, 7600 Sand Point Way NE, Seattle, USA)

We present results from numerical modelling of DMS measurements made during Lagrangian #B of the Southern Hemisphere Marine Aerosol Characterization Experiment ACE-1, that has been conducted in Nov/Dec 95 over the South-west Pacific Ocean, South of Australia. We study the interaction of the different physical and chemical processes controlling DMS in the unpolluted marine boundary layer (MBL), i.e. DMS emission from horizontally inhomogeneous sources, its advective and turbulent transport, entrainment of DMS-poor air into the MBL, and DMS oxidation. Note that the MBL encountered during ACE-1 Lagrangian #B is characterized by warm air moving southward over colder water, resulting in a stable shear-driven MBL, so that the turbulent vertical mixing of the air column is not always complete. The mesoscale meteorological model MésoNH, together with a coupled online chemistry module, is applied to this situation in two configurations: (i) as a 1D moving column model, which is particularly adapted to the Lagrangian measurement strategy, and (ii) as a 3D eulerian model using a horizontal resolution of 20km covering the ACE-1 region.

$nssSO_4^{2-}$, MSA AND THEIR RATIO IN MEDITERRANEAN MARINE AEROSOL

G. Piccardi, S. Becagli, R. Traversi, R. Udisti (Dept. of Environ. Anal. Chem., Univ. of Florence. Via G. Capponi, 9 - 50121 Florence, Italy.)
V. Boccini, O. Le Bolloch (International Marine Centre - Loc. Sa' Mardini, 09072 Torregrande - OR, Italy).
S. Guerzoni (Ist. Geologia Marina / CNR - Via Gobetti 101, 40129 Bologna, Italy)

This work reports preliminary data on the presence of methanesulphonic acid (MSA) in aerosol and rainfall collected in three Mediterranean sites (Italy), one in Sardinia (Torregrande-Or) and two in Tuscany (Leghorn and Florence). The samples were analysed to determine the main and trace components, with particular regard to sulphur biogenic compounds as non sea salt sulphate ($nssSO_4^{2-}$) and MSA. Mean MSA values in rainfall are 9 and 7 µg/l for Torregrande and Florence respectively, while the aerosol mean is approximately 0.01 µg/m³ in both coastal sites (Leghorn and Torregrande). The mean $nssSO_4^{2-}$ concentration values in rainfall are similar for Torregrande and Florence: 2200 and 2500 µg/l. The aerosol median values of $nssSO_4^{2-}$ for Torregrande and Leghorn are 2 and 4 µg/m³. The MSA/$nssSO_4^{2-}$ ratios are lower than 1% for rainwater and aerosol.

OCEANIC DMS EMISSION - SIMULATIONS WITH AN OGCM

K. D. Six (Max-Planck-Institut für Meteorologie, Bundesstraße 55, 20146 Hamburg, Germany)
F. J. Dentener (Utrecht University, Institute for Marine and Atmospheric Research (IMAU), Princetonplein 5, NL-3584 CC Utrecht, The Netherlands)

Oceanic sulfur emissions as dimethylsulfide (DMS) provide the largest contribution to the natural atmospheric sulfur cycle. Large uncertainties of the magnitude and regional distribution of the oceanic sulfur source exist. Earlier attempts to quantify the oceanic DMS emission were either based on extrapolation of very sparse data or based on correlations of DMS with chlorophyll distributions. We present here results of simulations of the oceanic sulfur cycle with a global three-dimensional biogeochemical ocean circulation model. The model includes a simple plankton dynamic which controls DMS production in sea water. DMS decays via three pathways : bacterial removal, photolysis and exchange with the atmosphere. Simulated DMS concentrations agree, in general, with observations. The model performs similar regional correlations between chlorophyll and DMS as observed. Sensitivity studies with respect to a globally uniform warming by two Kelvin show an increase of the DMS evasion of about 10%.

ST23/OA28 Heterogeneous processes of ozone destruction in the stratosphere and troposphere

Convener: Wahner, A.
Co-Convener: Rossi, M.J.

POLAR STRATOSPHERIC CLOUDS CLIMATOLOGY BASED ON LIDAR OBSERVATIONS AT MCMURDO STATION (78S,167E) FROM 1993

A. Adriani, CNR-IFA, Via G. Galilei, c.p. 27 - Frascati (Rome)- ITALY G. Di Donfrancesco, ENEA-Amb, Via Anguillarese, 301 - Rome - ITALY
G.P. Gobbi, F. Cairo and M. Viterbini CNR-IFA, Via G. Galilei, c.p. 27 - Frascati (Rome)- ITALY

Observations of Antarctic polar stratospheric clouds (PSCs) by ground- based LIDAR were carried out at McMurdo Station (78S, 167E) every year during the polar winter starting in 1993. The probability of PSCs occurence above the station has been estimated and, during the typical PSC season extending from early June to late September, values higher than 60% at about 25 Km of altitude were found during July. Evidence of HNO3 and H2O irreversible losses in the stratosphere due to PSC particles sedimentation during July was inferred from the pattern that PSC formation probabilities drop markely in the 15 to 25 Km region by early August, altought temperatures remain low enough in that region until mid-September. Occurences of different types of PSCs during the year were examined in terms of temperature formation and Ertel potential vorticity.

LABORATORY INVESTIGATION ON THE HETEROGENEOUS NO_x CHEMISTRY ON TROPOSPHERIC AEROSOLS

M. Ammann, M. Kalberer, U. Baltensperger, L. Tobler, C. Zellweger, F. Li, E. Rössler, D.T. Jost, D. Piguet and H.W. Gäggeler (Paul Scherrer Institute, CH-5232 Villigen, Switzerland, and University of Bern, Freiestrasse 3, CH-3012 Bern, Switzerland)

Heterogeneous interactions on aerosol particles strongly influence the oxidizing capacity of the troposphere either by removing photo-oxidants from the gas phase or by promoting their formation by surface chemical processes. In this laboratory investigation we measured the sticking coefficients of NO_2 on model aerosols, i.e. carbonaceous particles and salt aerosols (NaCl, $NaNO_3$, NH_4SO_4). We used an in situ experimental approach, where the NO_2 was reacted with the aerosol in a flow tube reactor under controlled temperature and humidity conditions and at low NO_2 concentrations, both in presence and absence of ozone. The sensitivity required for this kind of experiments was achieved by using the radioactive tracer ^{13}N with a half-life of 10 min. Gas phase products and particle bound species were trapped in a series of selective denuders and a particle filter, respectively, to each of which a detector was attached measuring the activity from the decay of ^{13}N. Where appropriate, a chemiluminescence detector was used to measure NO_2 concentrations in the ppt range. The results obtained with this in situ approach are compared to recent results obtained with bulk materials, and the implications of the investigated reactions for atmospheric chemistry are discussed with respect to the removal of NO_2 from the gas phase and the modification of the aerosol surface.

NEW DEVELOPMENTS FOR THE DETERMINATION OF THE OXIDATION CAPACITY OF THE ATMOSPHERE

K. Bächmann, P. Ebert, M. Kibler, A. Mainka, S. Schlomski and B. Tenberken (Technische Hochschule Darmstadt, Fachbereich Chemie, Petersenstr. 18; D-64287 Darmstadt, Germany)

Organic acids and carbonyl compounds are the first stable intermediates in the oxidation of hydrocarbons. The strategy of our work is to use these compounds as sensors for the determination of the oxidation capacity of the atmosphere. The concentration ratio and the time dependency between specific (e.g. homologues) pairs of aldehydes and carboxylic acids enable a valuable insight into the present status of photochemistry in the sampled air mass. Therefore, diurnal profiles with short time resolution (< 1 h) in conjunction with the low mixing ratios (pptv-ppbv range) require the development of new analytical methods. Additional information on chemical reactions of organic compounds in the atmosphere can be obtained by collecting size classified raindrops during precipitation. Using conventional sampling methods of aerosol particles the determination of volatile organic compounds (VOC) is not possible without discrimination due to the sampling procedure. A new method is presented to measure the mean aerosol particle size of VOCs in the atmosphere without discrimination effects by sampling size classified raindrops and analysing them for their chemical content. For the investigation of the chemistry in clouds it is necessary to know more details concerning the formation of clouddroplets. A new sampling method was developed for the determination of the chemical content of single cloud- and fogdroplets.

REDISTRIBUTION OF CHEMICAL SPECIES BY ICE-PHASE MICROPHYSICAL PROCESSES IN A SUMMER CUMULONIMBUS CLOUD.

N. Audiffren and S.Cautenet (Laboratoire de Météorologie Physique, CNRS/OPGC, Université Blaise Pascal, 24 Av des Landais 63177 Aubiere France).

Until now, ice-phase-related microphysics has been poorly addressed in studies concerning interactions between chemistry and heterogeneous cloud processes. However, it is well known that ice crystals can efficiently incorporate aerosols and chemical products, particularly during the riming processes. Hence, it is worthy to try to assess impact of ice-phase processes compared to aqueous-phase processes.

In the framework of a 2D convection model, using Stephen's parameterization for ice phase microphysical processes, uptake of chemical species such as H_2O_2, and SO_2 are analyzed, while gas phase and aqueous phase chemical reactions are taken into account with the mean of a fully coupled chemical module describing photochemistry of ozone precursors. Consequences on the whole chemical system and evaluation of relative contributions of ice-phase-related processes are studied.

INFRARED SPECTROSCOPIC INVESTIGATIONS OF REACTIONS ON SULFURIC ACID AEROSOL MIMICS.

P. Beichert and O. Schrems, AWI-Bremerhaven, Am Handelshafen 12, 27570 Bremerhaven, Germany. email: pbeichert, oschrems@awi-bremerhaven.de

A new apparatus for investigations of sulfuric acid films at low temperatures has been developed. The sulfuric acid films are produced via the reaction of SO_3 with water on a silicon substrate. This substrate is placed in a cryostat under an IR-microscope. The temperature regulation is achieved by a stream of cold nitrogen gas and electric heating of the cryostat. The sulfuric acid films, their concentrations and their temperature dependence are characterized by RAIR and transmission-IR-spectra. The gas phase over the sulfuric acid films is monitored by a quadrupole mass spectrometer. Stratospheric sulfuric acid concentrations can be accomblished by maintaining a constant water vapor pressure in the cell. The sulfuric acid films were prepared and exposed to the sink gases HCl or HNO_3. In addition we codeposited SO_3/H_2O and HNO_3 or HCl at low temperatures (130 K, no reaction of SO_3 with H_2O) and heated the resulting film to stratospheric temperatures. During this procedure, the SO_3 reacted quantitatively with the excess water to H_2SO_4 and some of the HNO_3 or HCl is released into the gas phase. These doped films were then exposed to relevant trace gases. The uptake of the trace gases as well as the formation of reaction products released into the gas phase are monitored by Quadrupole mass spectrometry, while the IR-spectra allow to follow changes in the solid phase.

DUAL WAVELENGTH RAMAN LIDAR OBSERVATIONS OF TROPICAL CIRRUS CLOUDS DURING ALBATROSS CAMPAIGN

G. Beyerle (Alfred Wegener-Institute, Potsdam, Germany, currently at JPL, California Institute of Technology, POB 367, Wrightwood, CA 92397-0367, USA)
J. Schäfer and O. Schrems (Alfred Wegener Institute, Bremerhaven, Germany)
R. Neuber and P. Rairoux (Alfred Wegener Institute, Potsdam, Germany)
I.S. McDermid (JPL, California Institute of Technology, Wrightwood, USA)

First results from lidar observations of tropical cirrus clouds above the Atlantic ocean during the ALBATROSS campaign (Atmospheric chemistry and lidar studies above the Atlantic ocean related to ozone and other trace gases in the tropo- and stratosphere) in October-November 1996 are presented. The measurements were performed aboard the German research vessel POLARSTERN between 35°N and 45°S. In the tropics cirrus clouds were frequently observed in the altitude range 12 - 16 km. Between 23.5°N and 23.5°S in 44% of the observations maximum volume depolarizations exceeded 0.1; in the subtropics (23.5° - 30°S and 23.5° - 30°N) this percentage was only 11%. Often several distinct layers could be distinguished within the cirrus cloud where the highest layers were reaching tropopause altitude. Based on the ratio of aerosol backscatter coefficients at wavelengths of 355 and 532 nm an estimate of the cirrus particle sizes is derived within the framework of Mie scattering theory. As Mie theory is based on the assumption of spherical particles the analysis is applied to measurements with aerosol depolarization less than 0.1 only. We find that the dependence of the ice water content (IWC) on temperature T can be parameterized by the linear fit IWC = $\exp(-32.35 + 0.114\ K^{-1}\ T)$ g/m^3.

ON THE ROLE OF HETEROGENEOUS PROCESSES ON THE SULFATE AEROSOLS IN ESTIMATION OF THE IMPACT OF MOUNT PINATUBO ERUPTION AND SUPERSONIC AVIATION ON THE OZONE LAYER

I. G. Dyominov and A. M. Zadorozhny (Novosibirsk State University, Novosibirsk, 630090, Russia)

2-D zonally-averaged dynamical/radiative/photochemical model of the troposphere and stratosphere is used for study of global impact of mount Pinatubo eruption (June 15, 1991) and NO_x and SO_2 emission from supersonic aircraft in the period of 1990-2015 on the ozone layer. A model takes into account aerosol physics for calculation of a sulfate aerosol layer consisting from particles with size 0.0064 μm ≤ r ≤ 5.2 μm. It is shown that volcanic discharges and supersonic aviation emission of SO_2 cause a many-times increase of effective surface of sulfate aerosol particles in the entire studied range. In the case of Pinatubo eruption, due to heterogeneous processes $ClONO_2 + H_2O(s) \rightarrow HOCl + HNO_3$, $ClONO_2 + HCl(s) \rightarrow Cl_2 + HNO_3$ and $HOCl + HCl(s) \rightarrow Cl_2 + H_2O$, on the surfaces of these particles chemically inert HCl and $ClONO_2$ transform in to active chlorine components. This leads to a significant decrease in total ozone, especially in tropical latitudes and over Antarctica. In the case of NO_x and SO_2 supersonic jet emission, N_2O_5, $ClONO_2$ and $BrONO_2$ hydrolysis reactions on the surface of sulfate aerosol layer particles lead to almost a five-times decrease in extra NO_x components as compared to gas-phase chemistry. The latter causes a significant decrease in the ozone depletion. This effect still more increases (about double) when SO_2 injected from aircraft in the form of sulfate particles.

ACTIVATION OF HALOGENS VIA HOBr IN THE TROPOSPHERE - A LABORATORY STUDY

S. Fickert (Max-Planck-Institut für Chemie, Department of Atmospheric Chemistry, Postfach 3060, D-55020 Mainz)
J. Adams, F. Helleis, G.K. Moortgat, J.N. Crowley

The activation of bromine via uptake of HOBr on seaspray aerosol is of great potential interest for the chemistry of the remote- and polar- marine boundary layer. Photochemically active species can be produced according to the following reaction scheme:

$$HOBr + Br^- + H^+ \longrightarrow Br_2 + H_2O$$
$$HOBr + Cl^- + H^+ \longrightarrow BrCl + H_2O$$
$$XBr + h\nu \longrightarrow X + Br \qquad (X = Br, Cl)$$

Subsequent reactions of these halogen atoms, especially Br, with ozone, are part of an autocatalytic cycle, which, via heterogeneous processing, further destroys ozone. Laboratory experiments to investigate the interaction of HOBr with seasalt-type liquids were carried out using a wetted wall flow tube coupled to a Mass Spectrometer. Measured reactant and product concentration profiles yield uptake efficiencies and thus infomation on diffusion and reaction rate coefficients.

TEMPERATURE AND PSC MEASURED BY LIDAR IN THE NORTHERN NORWAY.

F. Fierli, A. Hauchecorne (Service d'Aeronomie du CNRS, BP 3, 91371 Verrieres-le-buisson CEDEX, France)
H. Mehrtens (Institut fur Atmospharenphysik, D-18255 Kuhlungsborn, Germany)
K.H. Fricke (Physikaliches Insitut, University of Bonn, D-53115 Germany)

The heterogeneous chemistry reactions in presence of Polar Stratospheric Clouds (PSC) allow the activation of radical species, actives for ozone depletion. The formation and the nature of PSCs is very sensitive to the temperature and to its history. The ALOMAR lidar provides since 1995 aerosol backscatter measurements, and simultaneous temperature measurements in the stratosphere on an operational basis, only limited by cloud coverage.
We will briefly present the whole lidar system and we will show a review of PSCs events during 1995 and 1996 winters, when very cold temperatures have been reached. The correlation between temperature and aerosol parameters as surface ratio is studied in order to identify different formation mechanisms. Comparison with balloonborne measurements is useful to focus on particular study cases.
Preliminary results of 1996-1997 winter, in the frame of Leewave campaign will also be presented.

LABORATORY STUDIES OF HETEROGENEOUS INTERCONVERSION REACTIONS OF $ClNO_2$, $BrNO_2$ AND Br_2

A. Frenzel, V. Scheer, W. Behnke and C. Zetzsch (Fraunhofer Institut für Toxikologie und Aerosolforschung, Nikolai-Fuchs-Str. 1, D-30625 Hannover, Germany)

It is known that the heterogeneous reaction of N_2O_5 with chloride solution leads to the formation of $ClNO_2$. $ClNO_2$, $BrNO_2$ and Br_2 are released from mixed solutions of chloride and bromide. To get information about the possible equilibria between these species, we investigated the heterogeneous reactions of $ClNO_2$, $BrNO_2$, Br_2 on different solutions using a wetted-wall flowtube technique. $ClNO_2$ reacts fast with bromide solution to form $BrNO_2$, Br_2 and nitrite (a potential source of HONO). Hydrolysis of $BrNO_2$ is slower than that of $ClNO_2$, the observed uptake coefficient is 2.5×10^{-6}. The fast reaction of $BrNO_2$ with bromide is reversible and leads to bromine and nitrite, whereas $ClNO_2$ is formed with chloride solution. Several possible reaction mechanisms were tested and estimates of solubilities and reaction rate constants were drawn from a numerical model of the diffusion and reaction processes in the flowtube.

GROUNDBASED DOAS OBSERVATIONS OF STRATOSPHERIC HALOGENOXIDES AT GREENLAND AND AT THE JUNGFRAUJOCH.

A. Grund, E. Hegels, T. Klüpfel, B. Krug and D. Perner (Max-Planck-Institut für Chemie, Saarstr. 23, D-55122 Mainz)

During 1994/1996 stratospheric OClO has been detected solely within vortex air at Söndre Strömfjord, Greenland, by its absorption in zenith scattered sunlight. The morning behaviour of its vertical column showed the typical break between photolysis of the night-time OClO reservoir and its reformation from BrO and ClO. At solar zenith angles (SZA) of 92° the maximum vertical column was 2.5×10^{13} molec cm^{-2}. BrO was permanently present at Söndre Strömfjord as well as at the Jungfraujoch. Its variable slant columns reached up to 6×10^{14} molec cm^{-2} for SZA=88° and seemed to decrease slightly during the winter. The diurnal variations in connection with simple model considerations allows conclusions about the vertical distribution of BrO and the identity of its night time reservoir substances. An increase of BrO columns around noon which was first observed in March and July in Greenland appeared also at the Jungfraujoch. A possible tropospheric cause is discussed.

INDICATION FOR HETEROGENEOUS NO_3 LOSS IN THE POLLUTED ATMOSPHERE

M. Hausmann (Institut für Chemie und Dynamik der Geosphäre, ICG-3, Forschungszentrum Juelich, D-52425 Juelich, Germany)

The night-time NO_3 lifetime was investigated during a field experiment at a polluted rural site in Germany (Jülich, 50.93°N 6.36°E) in August 1990. NO_3 was detected by differential optical absorption spectroscopy (DOAS) along a 5.8 km light path. Nine night-time NO_3 concentration profiles were recorded. The maximum NO_3 concentrations ranged from 30 ppt (parts per trillion in volume) to 280 ppt and the maximum NO_3 lifetimes ranged from about 4 minutes to 40 minutes. An investigation of potential NO_3 loss processes strongly indicates that dominating heterogeneous NO_3 losses prevailed. For the apparent ambient aerosols a temperature dependent NO_3 accommodation coefficient between 0.05 and 0.6 was deduced ($\gamma(NO_3) = 1\times10^{-24}\exp\{15500K/T\}$). Furthermore, assuming a dominant net NO_3 loss via the homogeneous reaction of N_2O_5 with water vapour, an upper limit for the reaction constant $k_{max}(NO_3 + H_2O_{(g)}) = (2.0 \pm 0.3)\times10^{-22}$ cm^3s^{-1} (T = 290 K) was calculated.

THE IMPACT OF HETEROGENEOUS REACTIONS IN SULFURIC ACID AEROSOLS ON THE CHEMICAL COMPOSITION OF THE TROPOPAUSE REGION: A MODEL STUDY

J. Hendricks, H. Petry, E. Lippert and A. Ebel (Institute for Geophysics and Meteorology, University of Cologne, Albertus - Magnus - Platz, D-50923 Köln, Germany)

The condensed matter of the lower stratosphere and the upper troposphere is to a high fraction composed of acidic sulfate. During the last decade many studies have shown that heterogeneous reactions in liquid sulfuric acid aerosols play an important role in the chemistry of the lower stratosphere. The subject of the present study is the impact of heterogeneous chemistry on the chemical composition of the lowermost stratosphere and the upper troposphere.
The chemisty module of the 3D mesoscale EURAD model system was modified to treat heterogeneous conversions of N-, Cl- and Br- containing species in liquid sulfuric acid aerosols. Box- and 3D-calculations were performed to investigate the effects of heterogeneous chemistry and their sensitivity to aerosol loading. A special study was dedicated to the evaluation of the impact of heterogeneous reactions on the transformation of emissions from subsonic aircraft.
The simulations show that the presence of aerosols has considerable implications for the chemistry of the regarded altitudes. Heterogeneous reactions may strongly influence the NOx/NOy ratio. They also enhance the HOx production and are responsible for an activation of chlorine and bromine radicals. As a secondary effect the ozone concentration is reduced significantly. On the other hand the aircraft induced ozone production is amplified.

LABORATORY AND MODELING STUDIES OF TROPOSPHERIC AQUEOUS PHASE CHEMISTRY

H. Herrmann, H.-W. Jacobi, A. Reese, F. Wicktor, Th. Umschlag and R. Zellner
Institut für Physikalische und Theoretische Chemie, FB8
Universität GH Essen
Universitätsstr. 5, D-45117 Essen, Germany

Results from laboratory studies of the formation and reactivity of aqueous phase free radicals such as NO_3, SO_4^-, Br_2^-, Cl_2^- and RO_2 will be presented. Several laser-based methods have been developed and applied for the generation and time-resolved detection of the above species. The influence of organic compounds, including aromatics, on the chemistry within the aqueous tropospheric phase will be discussed. Results indicate that reactions of the above radicals with organic compounds may significantly change reaction sequences within droplets and aerosols dispersed in polluted airmasses when compared to clean air.
Contributions of free radical reactions to the overall chemical conversions in different tropospheric aqueous phase compartments (marine , urban continental and remote continental scenarios) will be assessed by means of the newly developed chemical aqueous phase radical mechanism (CAPRAM). This box model combines the well known gas phase RADM2 chemical mechanism with an extended set of aqueous phase chemical reactions taking into account about 200 chemical reactions in the aqueous phase. The effects of aqueous phase cloud and aerosol chemistry on tropospheric chemistry key species such as small organic peroxyl radicals and ozone will be discussed. An outlook on potential developments with regards to both modeling as well as necessary laboratory studies will be given.

AEROSOLS IN THE TROPOPAUSE REGION: VOLCANIC, AIRCRAFT, AND BACKGROUND

H. Jäger, F. Homburg, and R. Sussmann (Fraunhofer Institute for Atmospheric Environmental Research, IFU, Kreuzeckbahnstr. 19, D-82467 Garmisch-Partenkirchen, Germany)

A groundbased scanning lidar has been developed to investigate aerosols in the stratosphere and the upper troposphere. During periods which are not affected by explosive volcanism, source and sink mechanisms through the tropopause maintain a global level of stratospheric background aerosol, the so-called Junge layer.[1] The enhanced layer of stratospheric sulfuric acid aerosol after explosive volcanic eruptions (e.g. Pinatubo in 1991) becomes an aerosol source to the upper troposphere. Another source of aerosols to this region is longrange commercial air traffic which is polluting the upper troposphere and the lower stratosphere. Air traffic forecasts predict an average global growth rate of aircraft movements of about 5 to 6% per year while fuel consumption will increase with about 3% per year. Both, volcanic and aircraft aerosols act as cloud condensation nuclei to modify the upper troposphere cloudiness. Similar to thin cirrus which has been observed to form occasionally at the lower boundary of the Pinatubo aerosol layer, contrails forming in the wake of aircrafts may provide surfaces for heterogeneous processes. A combined lidar - CCD camera technique is in use to investigate additional cloudiness on a regional scale in air traffic corridors.

APPLICATIONS OF HIGH RESOLUTION INFRARED SPECTROSCOPY TO ATMOSPHERIC CHEMISTRY

M. S. Johnson and B. Nelander (University of Lund, MAX-Lab Box 118, S-221 00 Lund, Sweden)

We report on studies conducted at the beamline for infrared spectroscopy at the national synchrotron radiation research facility in Lund Sweden. The facilities combine a temperature controlled (90 - 350 K) multipass cell (150 m) with a high resolution Fourier transform interferometer, allowing detection in the range of 10 - 20,000 wavenumbers at 0.0012 wavenumber resolution. For typical molecules active in the infrared this implies a sensitivity to concentrations of gas phase species of 3E9 molecules/cc. We have used the instrument to study various systems involved with heterogeneous processing of chlorine compounds in the stratosphere.

HETEROGENEOUS CHEMISTRY IN AIRCRAFT PLUMES: CONSTRAINTS FOR UPTAKE COEFFICIENTS

B. Kärcher (Univ. München, Hohenbachernstr. 22, D-85354 Freising, Germany)

Recent *in-situ* emission measurements in the near-field of subsonic and supersonic aircraft exhaust plumes clearly show new volatile aerosol formation. Besides emitted non-volatile combustion aerosols (soot), volatile particle numbers exceeding 10^{16} particles per kg fuel burnt have been observed on several occasions. Microphysical models suggest that these aerosols offer peak surface area densities of 10^5 μm^2 cm^{-3} or more, so that heterogeneous processing can potentially become important in exhaust plumes. Under suitable conditions, contrails may form in the wake, providing typical initial water ice surfaces areas of similar magnitudes. In this contribution, we investigate characteristic timescales for heterogeneous reactions on the various particle surfaces present in diluting exhaust plumes. We will determine lower boundaries for uptake coefficients that are required for heterogeneous processing to evolve efficiently in decaying aircraft wakes. The results are applied to the particles observed in the plume of the supersonic Concorde in the lower stratosphere over New Zealand in 1994 to investigate possible uptake pathways. The potential for heterogeneous chemistry in non-persistent contrails is also briefly addressed.

A COMPARISON OF POLAR STRATOSPHERIC CLOUD MODELS USING TRAJECTORY CALCULATIONS

J. R. Knight, J. Austin and N. Butchart (Meteorological Office, London Rd., Bracknell, Berkshire, RG12 2SZ, U.K.)
K. S. Carslaw and Th. Peter (Max-Planck-Institut für Chemie, Mainz, Germany.)

As part of the CEC-supported TOPOZ (Towards the Prediction of Stratospheric Ozone) project, the chemical effects of a range of possible Polar Stratospheric Cloud (PSC) models are compared by using a photochemical box model integrated along Arctic isentropic trajectories computed using analysed winds. A PSC scheme which allows a choice of particles (ternary liquid aerosols, sulphuric acid tetrahydrate, nitric acid trihydrate and ice) in thermodynamic equilibrium is included in this formulation to determine the rates of the key heterogeneous reactions. Firstly, we present the results of calculations including the reactions of nitrogen and chlorine species on PSC surfaces. In addition, we investigate the potential rôle played by heterogeneous bromine reactions, focussing on the uncertainties that remain in reaction probabilities on solid particles. Finally, the results are compared with sample data from UARS, to give an indication of which models, if any, are appropriate for modelling Arctic PSCs.

THE ROLE OF BROMINE OXIDE AND PEROXY RADICALS DURING ARCTIC OZONE DEPLETION EVENTS IN NY ALESUND.

M. Martinez-Walter, T. Arnold, D. Perner, and R. Seuwen, Max-Planck-Institut für Chemie, Saarstr. 23, D-55122 Mainz

Depletion of ozone in boundary air during the arctic spring is known to be connected to bromine chemistry. During the EC-sponsored Arctic Tropospheric Ozone Chemistry (ARCTOC) campaigns at Ny Alesund, Spitsbergen, in April 1995 and 1996 BrO levels of 15 to 30 ppt have been found together with ozone decreasing from 40 ppb to virtually zero in air which extended to 1000m a.s.l. Those trace gases were observed by differential optical absorption spectroscopy (DOAS) along two lightpaths between 20 and 475m a.s.l. at various separations from ground. During sunny periods up to 8 ppt peroxy radicals were found by chemical amplification around noon (ROx-Box). The discussion will concentrate on the chemistry in comparison with that described by a chemical box model. The meteorological conditions and the back trajectories argue in favour of a primary halogen activation from the pack ice and its continuous recycling by heterogeneous reactions.

THE USE OF IN SITU MEASUREMENTS OVER ANTARCTICA TO CLASSIFY POLAR STRATOSPHERIC CLOUDS.

C.M. Mitas and T. Deshler (Dept. of Atmospheric Science, University of Wyoming, P.O. Box 3038, Laramie, Wyoming, 82071-3038, USA)

Polar stratospheric clouds (PSCs) play a major role in the destruction of ozone over Antarctica, by providing suitable liquid or solid particle surfaces for complex heterogeneous chemistry. The chemical composition and physical state of PSCs are not known accurately, although it is known that water and nitric acid are involved in the condensation process on pre-existing sulfuric acid solution droplets.
The main objective of this study is to analyze in situ aerosol data in terms of their temperature-volume relationship, and to compare these relationships with results from thermo-dynamical/chemical models of temperature-volume association. The temperature, aerosol volume, pressure, water vapor and sulfuric acid mixing ratio data were obtained from in situ aerosol measurements over McMurdo, Antarctica, during southern hemisphere spring and winter seasons. Profiles of nitric acid were obtained from CLAES and MLS satellite data for the same region and time period. Measurements from day to day were grouped based on the potential temperature. Preliminary results show that liquid aerosols are slightly more common than solid aerosols in the PSCs studied.

THE MOLECULAR DIFFUSION TUBE: MEASUREMENT OF RESIDENCE TIMES OF GAS MOLECULES ON SURFACES

T. G. Koch, F. F. Fenter and M. J. Rossi (Swiss Federal Institute of Technology, DGR/LPAS-EPFL, CH-1015 Lausanne)

A new apparatus has been designed in order to gain a quantitative understanding of the residence time of a gas molecule on a given surface: the molecular diffusion tube. The experiment, carried out under molecular flow conditions, involves sending a pulse of molecules through a narrow tube coated with a material of interest. The tube is typically 1 to 2 cm in diameter and up to 1 m in length. Since the number of gas-wall collisions in the tube is well defined and only dependent on the tube geometry, information on the magnitude of the interaction per collision can be extracted from the arrival time trace, measured by mass spectrometer at the exit of the tube. First results indicate that the residence time of water on room temperature Pyrex glass is of the order of 0.2 ms. An upper limit of 3 μs was measured for water on Teflon (PTFE). Nitrogen dioxide behaved like an ideal gas in both cases.
A Monte Carlo computer model which simulates interactive as well as non-interactive molecular gas flow through a given reactor geometry shows excellent agreement with the experimental data. Implications of our findings on the measurement of heterogeneous atmospheric rate constants in the laboratory will be discussed.

HETEROGENEOUS CONVERSION OF NITROGEN OXIDES ON $NaNO_3$ AEROSOL SURFACES

Th. F. Mentel (Institut für Atmosphärische Chemie, Forschungszentrum Jülich, D-52425 Jülich, FRG), J. Stier, M. Sohn and A. Wahner.

The conversion of N_2O_5 to HNO_3 on wet aerosol surfaces is the dominant tropospheric removal mechanism for NO_x during the night and in the wintertime:

$$N_2O_5 + H_2O_{Aerosol} \longrightarrow 2\,HNO_3.$$

The heterogeneous N_2O_5 hydrolysis on $NaNO_3$ aerosol was studied in a large reaction chamber with a volume of 260 m^3 and a surface/volume ratio better than 1 m^{-1}. N_2O_5 was produced in-situ by addition of O_3 to NO_2. The particles were generated by a nebulizer consisting of ten 'two-fluid' nozzles. The inital $NaNO_3$ aerosol number concentrations were up to $3\text{-}10^5$ cm^{-3}. The initial size distributions showed a CMD of 220 nm with a GSD of 2.07. Rapid coagulation lead to lifetimes of about 23 hours and to a CMD shift to larger sizes. Aerosol measurements were performed using an electrostatic classifier (SMPS, size range 0.02 to 1 μm) and a scattered light measuring system (PCS, size range 0.5 to 20 μm). The mixing ratios of the reactants NO_2, N_2O_5, and HNO_3 were measured simultaneously by high resolution FTIR spectroscopy, whereas O_3 and NO were monitored by UV absorption and chemiluminescence, respectively. In the presence of $NaNO_3$ aerosol a highly accelerated conversion of N_2O_5 to gas-phase HNO_3 was observed. The experimental results can be explained by an approximation of the heterogeneous process as a simple gaskinetic collision of N_2O_5 with the aerosol with an effective uptake coefficient γ of 0.01-0.001.

HETEROGENEOUS REACTIONS OF OZONE AND NITROGEN COMPOUNDS AT THE SURFACE OF SOOT PARTICLES

O. Möhler, K.-H. Naumann, H. Saathoff, and U. Schurath (Forschungszentrum Karlsruhe, Institut für Meteorologie und Klimaforschung, Postfach 3640, D-76021 Karlsruhe, Germany)

Combustion engines emit significant amounts of soot particles into the troposphere and stratosphere. Heterogeneous reactions at the soot surface may have an impact on the concentration of trace species like ozone and NO_x due to surface reactions and may therefore e.g. influence the ozone chemistry. The importance of such processes in competition with the gas-phase chemistry depends on their reaction probabilities and reaction mechanisms which are only poorly known.
We perform aerosol chamber experiments and run aerosol models to investigate such processes. Various soot aerosols from carbon sparc generators and flames are used and the experimental conditions are chosen to be close to atmospheric ones. The temperature can be varied between -90 and +60°C. The models describe the dynamic behaviour of soot aggregates as well as gas-phase and surface chemistry. First results on the reactivity of soot particles with respect to O_3, NO_2, and mixtures of ozone and nitrogen compounds will be discussed.

EXPERIMENTAL FINDINGS FOR HETEROGENEOUS OZONE DESTRUCTION IN CLOUDS AT MT. BROCKEN

D Moller, K Acker and W. Wieprecht (Brandenburg Technical University, D-03013 Cottbus, P.O.Box 10 13 44, Germany)

Theoretical studies using models with coupled gas and liquid phase chemistry suggested that not only the net formation of ozone could be reduced in clouds but also heterogeneous destruction could be possible. Several possible pathways of ozone sinks in clouds we discussed recently concerning first experimental findings of ozone depletion at Mt. Brocken. We often observed in the continuous record of ozone concentration that with passing clouds the ozone concentration decreases rapid, where the interstitial concentration is up to 50% lower than before the cloud event [Acker et al., 1995]. When the cloud is moved away, the ozone concentration increased again too around its former level. From the data set (more than 3000 1-hour samples) we found significantly differences in the chemical concentration of cloud water between events with and without ozone depletion. Using 3d back trajectory calculations and information on mesoscale cloud and precipitations fields we believe to support the idea of ozone depletion within clouds. The aim of this paper is to show a statistically significant effect of ozone depletion within clouds. Moreover, we would like to stimulate the discussion on the importance of heterogeneous processes for the mesoscale oxidant budget.

K. Acker, W. Wieprecht, D. Möller, G. Mauersberger, S. Naumann and A. Oestreich (1995) Naturwiss. 82, 86-89

IONIC SPECIATION IN COLD SULFURIC ACID

C.E.L. Myhre, O.W. Saastad and C.J. Nielsen (Department of Chemistry, University of Oslo, P.O.Box 1033 Blindern, N-0315 Oslo, Norway)

The ionic speciation of 10 to 80 wt % sulfuric acid has been investigated by Raman spectroscopy in the temperature region 295 to 213 K. The spectra of 10 to 70 wt % have been analyzed in terms of HSO_4^- and SO_4^{2-}, while solutions of more than 70 wt % probably also contain undissociated sulfuric acid. For all the solutions studied the degree of dissociation increases with decreasing temperature; the largest temperature dependence was observed for solutions around 50 wt %. A expression for the ionic speciation in sulfuric acid as a function of temperature and composition is presented. The observed ionic speciation is in good agreement with thermodynamic predictions for the more dilute solutions whereas there is a substantial discrepancy for concentrations above 50 wt %.

PEROXO SULFUR SPECIES IN COLD SULFURIC ACIDS, GENERATED BY NITRATE RADICALS

Thorvald Pedersen (University of Copenhagen, Institute of Chemistry, 5, Universitetsparken, DK 2100, Copenhagen, Denmark)
Daniel Christensen and Jeanette Ryttersgaard (University of Copenhagen, Institute of Chemistry, 5, Universitetsparken, DK 2100, Copenhagen, Denmark)

Raman spectroscopy in combination with titrimetry has been used to study the speciation of mono- and diperoxo sulfuric acids in sulfuric acid solutions of stratospheric relevance. At the time of submission only a qualitative conclusion can be made: Hydrogen peroxide does enter into equilibria with the peroxo acids under the circumstances. Equilibrium constants and rates are our objectives.

The peroxo species are thought to be formed by uptake of nitrate radicals during nighttime, followed by radical exchange with sulfate ions.

IS NIGHTTIME OXIDATION OF HCl BY NITRATE RADICALS IMPORTANT ON THE STRATOSPHERIC AEROSOL?

Thorvald Pedersen (University of Copenhagen, Institute of Chemistry, 5, Universitetsparken, DK 2100, Copenhagen, Denmark)
Morten Wagner Kristiansen (University of Copenhagen, Institute of Chemistry, 5, Universitetsparken, DK 2100, Copenhagen, Denmark)

A chemical model assuming a monodisperse sulfuric acid aerosol with droplet size 0.1 μm has been constructed. The model environment is assumed to be that of the mid-latitude lower stratosphere. The principal physical and chemical reactions taken into account are 1) (nighttime) uptake of nitrate radicals, 2) conversion of sulfate into sulfate radicals through reaction with nitrate radicals 3) conversion of water into hydroxyl radicals through reactions with either nitrate or sulfate radicals. Finally reactions of any of the radicals above with dissolved HCl to form Cl and subseqently Cl_2, which is then assumed to evaporate from the droplets.

Chlorine formation competes with build-up of peroxosulfuric acids and at the present stage the latter proces is favoured over the former according to the model.

DIFFUSIVITIES IN COLD SULFURIC ACIDS

Thorvald Pedersen (University of Copenhagen, Institute of Chemistry, 5, Universitetsparken, DK 2100, Copenhagen, Denmark)
Morten Wagner Kristiansen and Erik Jonas Pedersen (University of Copenhagen, Institute of Chemistry, 5, Universitetsparken, DK 2100, Copenhagen, Denmark)

The diffusivities (D) of several compounds found in the stratosphere are needed for modeling purposes. We have measured D for DMSO (dimethyl sulfoxide), DMSO2 (dimethyl sulfone) and HDO/$HDSO_4$ in 80, 70 and 60% D_2SO_4 and at -25°C, 0°C and 25°C. Measurements of the diffusivity of ^{15}N-nitrate is underway. Attempts to measure $D_2^{17}O$ and $D_2SO_3^{17}O$ have failed sofar, but attempts continue.
Using the Einstein-Stokes relation $D = C\frac{T}{\eta}$, where η is the (known) viscosity (function of temperature T), C was determined for the three acid concentrations for the substances mentioned.

OBSERVATION OF BROMINE-MONOXIDE IN THE LOWER ATMOSPHERE BY GROUNDBASED REMOTE SENSING AND ITS SIGNIFICANCE FOR THE GLOBAL BROMINE BUDGET.

D. Perner, H. Harder, E. Hegels, Th. Klüpfel (Max-Planck-Institut für Chemie, Saarstr. 23, D-55122 Mainz, Germany)
Ib Mikkelsen (Danish Meteorological Institute, Lynby Vej 100, DK-2100 Copenhagen)

Tropospheric BrO has been observed by groundbased zenith sky spectroscopy during tropospheric solar sunrise in the Arctic as well as in the Antarctic. Here we report on the observation of inorganic bromine compounds in tropospheric air at Söndre Strömfjord, Greenland in July/August 1995. Increasing BrO absorptions below a solar zenith angle of 80° were found to occur symmetrically around noon. That phenomenon can be explained by the competition of the increasing photolysis rate of bromine nitrate during a.m. and its reformation. The latter becomes overwhelming again towards sunset. The backtrajectories point to the Arctic as an important source of atmospheric bromine as already observed in several investigations and also during ARCTOC.

DIFFUSION AND SOLUBILITY OF STRATOSPHERIC TRACE GASES IN COLD AQUEOUS SOLUTIONS OF SULFURIC ACID

V. Proksch, O. Möhler, and U. Schurath (Forschungszentrum Karlsruhe, Institut für Meteorologie und Klimaforschung, Postfach 3640, D-76021 Karlsruhe, Germany)
S. Langenberg (Universität Bonn, Institut für Physikalische und Theoretische Chemie, Wegelerstr. 12, D-53115 Bonn, Germany)

Heterogeneous processes are known to play important roles in the chemistry of stratospheric ozone. In constructing models of heterogeneous reactions occuring in the stratosphere, a complete data set for the involved physico-chemical processes in the gas and particle phases is required.
We have improved a recently developed capillary column method to measure diffusion coefficients and solubilities of trace gases in thin film sulfuric acid solutions (film thickness between 1 and 2 µm, 40 to 80 wt% sulfuric acid) at stratospheric temperatures down to -90°C. The trace gases are detected using a novel ion trap mass spectrometer. The experimental approach is described on the poster and first results are discussed.

ADSORPTION OF HCl ON ICE WITH KNOWN SURFACE AREA

L. Rey and F. Dominé (Laboratoire de Glaciologie et Géophysique de l'Environnement, BP 96, 38402 St Martin d'Hères cedex FRANCE)

The adsorption of trace gases on solids are key steps in numerous atmospheric chemical processes. One of the essential parameters that characterize adsorption is the surface coverage θ of the gas on the solid as a function of trace gas partial pressure. In most cases, however, such as the adsorption of HCl on ice, as relevant to ozone depletion, large uncertainties remain on the surface coverage because the specific surface area of the ice used in the adsorption experiments was never actually measured.
We have therefore built a new system where we can determine the ice surface area and porosity before and after our HCl adsorption experiment. Results dealing with the adsorption of HCl on various types of ices (natural snow, porous and non porous ices), at different temperatures, will be presented and compared with previous results by other authors to stress the importance of the characterization of the solid in the interpretation of adsorption experiments.

CHEMISTRY AT THE SURFACES OF MODEL STRATOSPHERIC CLOUD PARTICLES

J. T. Roberts, J. Duncan, B. Guldan, J. Schaff, and L. Schindler (Department of Chemistry, University of Minnesota, Minneapolis, MN 55455, USA)

Chemical reactions that occur in the surface and near surface regions of ice and sulfuric acid particles play a critical role in formation of the Antarctic ozone hole. We seek to understand the underlying mechanisms of these surface-mediated chemical transformations. Our experimental method involves the study of ultrathin (<200 Å thick) films of ice and sulfuric acid as surrogates for polar stratospheric cloud particles. The films, which are deposited on single-crystal metal substrates, serve as convenient samples on which to study adsorption and desorption kinetics, and adsorbate structure. Importantly, the large surface area to volume ratios of the films make it experimentally simple to distinguish between surface- and bulk-mediated processes. The following aspects of our recent work will be discussed: (i) the extent to which ice surface structure dictates reactivity, (ii) the surface chemical properties of solid and liquid sulfuric acid, (iii) the thermal and photochemistry of stratospherically abundant chlorine oxides on ice, and (iv) the mechanistic consequences of the fact that the surface of an atmospheric ice particle is highly dynamic, i.e. the evaporation and condensation rates of water on ice are very large.

A REMPI-MS technique to monitor selected atmospheric trace constituents in the ppt range

S. Schmidt, Th. Benter and R. N. Schindler
Institut für Physikalische Chemie der Christian-Albrechts Universität zu Kiel, Ludewig Meyn Straße 6-8, D-24098 Kiel, Germany

Resonance enhanced multiphoton ionisation (REMPI) in a supersonic molecular beam in combination with a mass spectrometer (MS) has been established as a highly selective and very sensitive detection method in the analysis of trace constituents of the atmosphere.
In this work a new set-up for the MS gas inlet and the ion source are presented for on-line measurements of traces with ppt concentrations at atmospheric pressure. The ionisation region was placed in the expanding jet directly behind the gas inlet nozzle. The increase in sensitivity is based on the high particle density in the ionisation region and the cooling through adiabatic expansion. The geometry of the nozzle and the skimmer in the ion source were optimised by ion trajectory calculations.
In the presented experimental set-up detection sensitivities were achieved in the range of 1-10 ppt for different trace gas compounds (NO, CH_3CHO, aromatics).
The detection limits have been determined in He, Ar and synthetic air and were found to be independent on the carrier gas. This technique is about 500 times more sensitive than other known methods.

LAMOCS: A EUROPEAN RESEARCH PROJECT INVOLVING LABORATORY AND MODELLING STUDIES OF HETEROGENEOUS REACTIONS IN THE STRATOSPHERE

O. Schrems (Alfred Wegener Institute for Polar and Marine Research, Am Handelshafen 12, D-27570 Bremerhaven, Germany)

LAMOCS (= Laboratory Studies and Modelling of Heterogeneous Chemistry in the Stratosphere) is a research project funded by the European Commission and jointly performed by 8 laboratories (Alfred Wegener Institute Bremerhaven (O.Schrems), University of Copenhagen (T. Pedersen), University of Helsinki (M. Räsänen), University of Lund (B. Nelander), Norewegian Institute of Air Research, Kjeller (F. Stordal), Technical University of Vienna (E. Knözinger), University of Hannover (H. Willner) and the University of Oslo (C. Nielsen)). The main goals are studies of heterogeneous chemical processes which take place on stratospheric sulphuric acid aerosol (SAA) and which influence the partitioning of hydrogen, halogen and nitrogen species in the lower stratosphere over middle to high latitudes. All laboratory investigators in the LAMOCS project use a common reaction medium of a composition close to that of the stratospheric aerosol, i.e. 60-80 wt% sulphuric acid in water with trace constitutents added in the right quantities. Two different models - a two-dimensional model and a trajectory model - are used in this project to study the effects of new chemical reactions that are investigated in the laboratories. The chemical scheme in the trajectory model is identical to the one used in the 2-D model, including gas phase and heterogeneous reactions. Backward trajectories are calculated on given isentropic surfaces and they are based on the ECMWF winds. An overview of the project and results obtained from the participating laboratories will be presented.

UPTAKE OF ORGANIC COMPOUNDS BY LIQUID WATER: A DROPLET TRAIN STUDY

F. Schweitzer, L. Magi, Ch. George and Ph. Mirabel (Equipe de Physico-chimie de l'Atmosphere - CNRS, 28 rue Goethe F-67083 Strasbourg)

Organic compounds are important for a correct description of the atmospheric chemistry. They may be directly emitted by both natural and anthropogenic sources or be present as secondary pollutants. In this latter case, they may be produced, for example, during the degradation of methane, dimethyl sulphide or aromatics leading, respectively, to methyl hydroperoxide (CH3OOH), methanesulfonic acid (CH3SO3H) and glyoxal (CHOCHO). All these species may interact with the atmospheric condensed phase (fog, cloud) and act as oxidants, or oxidation inhibitors or finally as aerosol precursors. It is therefore important to understand how efficient these gas/liquid interactions may be. We performed such a study using the droplet train technique. Current results describing the effect of temperature, aqueous phase composition on the uptake rate will be presented.

KINETICS OF THE UPTAKE OF NO_3 ON NACl AND KBr SALT

S. Seisel, F. Caloz, F.F. Fenter and M.J. Rossi (EPFL, LPAS, CH-1015 Lausanne, Switzerland)

The NO_3 radical is known to play an important role in tropospheric nighttime chemistry. We measured the uptake kinetics of NO_3 on NaCl and KBr salt using a low pressure flow reactor equipped with MS and LIF detection. NO_3 was produced *in situ* by thermal decomposition of N_2O_5 resulting in a yield of 50 % NO_3 and 150 % yield in NO_2 with respect to N_2O_5. The uptake of NO_3 on NaCl and KBr powder (100-160 µm grain diameter) was found to be fast with an uptake coefficient of $\gamma = 0.1$. Furthermore, we found a strong dependence of the NO_3 uptake on the total external surface area of the salt sample. By using salt samples of well-defined total external surface and applying a diffusion correction to the obtained uptake rate of NO_3 we are able to determine the true uptake coefficient γ_0.
It is assumed that atomic Cl and Br are the products of the reaction between NO_3 and the corresponding salt. However, during the reaction of NO_3 with NaCl HCl was observed as the only gaseous product in 100 % yield with respect to NO_3. BrO and Br_2 were identified as reaction products of the reaction of NO_3 with KBr. All observed products may be formed in secondary reactions of the halogen atom and additional experiments are underway with the goal to study the primary products of the NO_3/salt heterogeneous reaction.

THE EVOLUTION OF POLAR STRATOSPHERIC CLOUDS ABOVE SPITSBERGEN

K. Stebel* and O. Schrems (Alfred Wegener Institute for Polar and Marine Research, Am Handelshafen 12, D–27570 Bremerhaven, Germany)
* now: Swedish Institute of Space Physics, Box 812, S–98128 Kiruna, Sweden
R. Neuber, G. Beyerle, J. Biele, P. Scheuch, H. Schütt and P. von der Gathen (Alfred Wegener Institute for Polar and Marine Research, Telegraphenberg A43, D-14473 Potsdam, Germany)
B. Knudsen (Danish Meteorological Institute, Lyngbyvej 100, DK-2100 København, Denmark)

Multiwavelength lidar observations of Polar Stratospheric Clouds (PSCs) are performed at the Arctic NDSC primary station in Ny-Ålesund, Spitsbergen (79 °N, 12°E) since winter 1991/92. The Spitsbergen lidar data represent the 'normal' development of Arctic PSCs in the center of the Arctic vortex. The high variability of the minimum temperatures in the Arctic is reflected in the observation frequencies of PSCs. PSCs above Spitsbergen are mainly of type I, as temperatures only seldom reach the water frost point. Lidar depolarization measurements in combination with back trajectory analyses of airmass thermal history of PSCs are used to distinguish distinct classes of type I PSCs. PSC observations of winter 1992/93, 1994/95 and 1995/96 were analysed to study the evolution of PSCs during the winter season. The PSC development in winter 1995/96 is regarded as typical for a 'cold' winter in the Arctic with a normal background aerosol content. The development shows three distinct appearances of the PSC layer during early, mid– and late–winter, which will be discussed.

VALUES OF ENTHALPY CHANGES IN SOLVATION REACTIONS OF IONS AND ION CLUSTERS IN SOLUTIONS

N.B.Zolotov and G.V.Karpov (Semenov Institute of Chemical Physics of Russian Academy of Sciences, 117977, Kosygin Str.,4, Moscow, Russia)

The enthalpy changes, ΔH, for 14 solvation reactions for ions Na and ion clusters $Na^+ Et_m(H_2O)_n$ in solution have been determined, using the experimental data. The solvation consists in addition one or two ethanol molecules to ions and ion clusters under equilibrium conditions:

$$Et \rightleftarrows Na^+ Et_{m+1}(H_2O)_n \quad (I)$$

$$Na^+Et_m(H_2O)_n + 2\,Et \rightleftarrows Na^+ Et_{m+2}(H_2O)_n \quad (II)$$

(m, n = 0,1,2,...; Et - ethanol molecule). As an example, some values of ΔH, kJ/mole, are: - 30,9 (m=n=0, (I)); - 46,4 (m=n=0, (II)); - 24,7 (m=0, n=1, (I)); - 36,1(m=0, n=1, (II)); -16,7 (m=n=1, (I)); - 32,6 (m=n=1, (II)). These results have been obtained by the mass spectrographic method of field evaporation of ions out of solutions, based on evaporation of these ions in vacuum by a strong electric field [1]. There is no any other methods for the ΔH determination in solutions. In experiments the solution of NaI in water-ethanol solvent was used; concentration of NaI was 0,08 mole/l, the mole portions of ethanol and water were 0,76 and 0,24 correspondently. The solution temperature was in region of 219-248 K. [1]. N.B.Zolotoy, G.V.Karpov. Doklady Physical Chemistry, 1996, v.348, No.4-6, p.137.

HETEROGENEOUS CONVERSION OF NITROGEN OXIDES AT URBAN CONENTRATIONS AND LOW HUMIDITIES

M. Sohn (Institut für Atmosphärische Chemie, Forschungszentrum Jülich, D-52425 Jülich, FRG), Th. F. Mentel and A. Wahner.

The heterogeneous conversion of nitrogen oxides to HNO_3 on aerosol surfaces is the most important tropospheric loss path for NO_x during the night and in the wintertime. The nocturnal chemistry of the NO_2/O_3 system was studied at urban atmospheric NO_x concentrations and low relative humidities (< 2%). The experiments were performed at ambient temperature and pressure in a large reaction chamber with a volume of 260 m^3 and a surface/volume ratio better than $1 m^{-1}$. The organic aerosols formed upon the addition of O_3 to NO_2 in ambient air. The mixing ratios of NO_2, N_2O_5, and HNO_3 were measured simultaneously by high resolution FTIR spectroscopy. Since the experiments were carried out at maximum N_2O_5- and HNO_3-mixing ratios of a few ppb, a three mirror type White cell with an optical path length of up to 720 m, modified by two pairs of diagonal flat mirrors, was set up. O_3 and NO were monitored by UV absorption and chemiluminescence, respectively. Aerosol measurements were performed using an electrostatic classifier (SMPS, size range 0.02 to 1 µm). Model calculations including the most important gas-phase reactions of the NO_y system could not explain the observed N_2O_5-HNO_3 conversion rate at low humidities. A possible heterogeneous reaction on organic aerosols will be discussed.

Airborne Polar Experiment: the 1996-1997 winter Arctic Mission, Rovaniemi, Finland

L. Stefanutti*, A. Adriani^, A. R. MacKenzie#, S. Balestri&

* CNR-IROE, Via Panciatichi, 64, Florence, Italy
^ CNR-IFA, Via G. Galilei, cp 27, Frascati, Rome, Italy
# Centre for Atmospheric Science, University of Cambridge, Cambridge, United Kingdom
& APE Management Committee,via Jacopo Nardi 65, Florence, Italy

The first mission of the Airborne Polar Experiment (APE) will be performed in Rovaniemi, Finland, from December 1996 to January 1997. The mission will use a Russian high-altitude aircraft, the M55 Geophysica, and aims to study the characteristics and formation processes of polar stratospheric clouds (PSCs). It is planned that the aircraft will fly directly inside PSCs at altitudes of up to 21 km, investigating the effects of the Scandinavian Alps on PSC formation, and carrying out the first search for PSC activity over the Ural mountains. The payload is composed of several in-situ and remote sensing instruments, which will measure particle size distributions and backscatter characteristics, short-lived chemical species including ClO, ozone, and water vapour. Dynamical, chemical and microphysical modelling will be drive and assist development of the campaign. The APE campaign will be co-ordinated with the POLECAT mission. POLECAT will use a DLR falcon aircraft equipped with the OLEX Lidar system, in combination with sophisticated mesoscale dynamical modelling and microphysical calculations, to study lee wave PSC events.

ST24/OA29 The role of vegetation emissions in tropospheric chemistry

Convener: Versino, B
Co-Convener: Hewitt, N.

EMISSION OF TERPENES AND ISOPRENE FROM THE DIFFERENT OAK SPECIES *Quercus ilex* L., *Quercus pubescens* L. AND *Quercus agrifolia* L.

P. Ciccioli, E. Brancaleoni, A. Cecinato, M. Frattoni (Istituto sull'inquinamento Atmosferico del C.N.R, Via Salaria km 29300, C.P. 10, 00016 Monterotondo Scalo, Italy)
V. Simon, L. Dutaur, J.L. Fugit, L. Torres (Institut National Polytechnique de Toulouse, Ecole Nationale Supérieure de Chimie, Chimie Energie et Environnement, 118, route de Narbonne, 31077 Toulouse Cedex, France)
J. Kesselmeier, K. Bode, L. Schäfer, A. Wolf (Abt. Biogeochemie, Max-Planck-Institut fur Chemie, Johann-Joachim Becher Weg 27, D-55128 Mainz, Germany)
F. Loreto (Istituto di Biochimica ed Ecofisiologia Vegetali del CNR., Via Salaria km 29300, C.P. 10, 00016 Monterotondo Scalo, Italy)

The objective of our study within the frame of the EU-project "B E.M.A." was to compare the monoterpene and isoprene emissions of two important oak species representative for the Mediterranean ecosystem, namely, *Quercus ilex* (Holm oak), a strong monoterpene emitter, and *Quercus pubescens* (White oak), a strong isoprene emitter. Additionally we included the Californian oak species *Quercus agrifolia* (Coast Live Oak), which is anatomically and morphologically comparable with *Quercus ilex*. The data show that Live Oak and Holm oak, though looking identical, differ as far as the emission of terpenoids is concerned, emitting isoprene or terpenes, respectively. Data from simultaneous measurements of the isoprene emitting White oak and the monoterpene emitting Holm oak as well as additional investigations on *Quercus agrifolia* (Coast Live Oak) fit perfectly with an algorithm, describing the emission as being dependent on light and temperature. The dependence of monoterpene emissions from PAR and temperature and the similar behaviour of isoprene and terpene emitters points to close metabolic pathways, which is in full agreement with recently described evidence for the production of *Q.ilex* monoterpenes by the same pathway as known for isoprene. Hence, modelling terpene emissions for the main Mediterranean oak species can be performed by the same procedure as for isoprene.

FLUXES OF SEVERAL VOC EMITTED BY ORANGE TREES DETERMINED BY THE VERTICAL GRADIENT METHOD

C. Cieslik and A. Calogirou, D. Kotzias, B. Larsen (Environment Institute, Joint Research Center, Ispra, Italy)
P. Ciccioli (Istituto Inquinamento Atmosferico CNR, I-00016 Monterotondo Scalo, Italy)

Orange tree orchards extend over large areas along the Spanish Mediterranean coast and their emissions of organic substances like limonene, linalool, etc., are likely to play a role in atmospheric photochemistry leading to ozone formation. It is therefore essential to gain knowledge on the emission fluxes of these compounds. During two measuring campaigns, conducted in the frame of the BEMA project of the European Commission, in July 1995 and in April-May 1996, the surface fluxes of a series of volatile organic compounds were determined using the vertical gradient method. The concentration gradients were measured at three levels through an automated sampling system and GC-MS analysis. The eddy diffusion coefficients were derived from sonic anemometer data. The gradients observed were mostly monotonous, indicating a good homogeneity, checked by other observations. VOC emissions, dominated by limonene, linalool and sabinene, followed a daily trend similar to that of evapotranspiration fluxes, indicating that stomatal processes could be in part responsible for the emission.

A LABORATORY SCREENING STUDY OF MEDITERRANEAN OAK SPECIES FOR VOC-EMISSIONS

O. von Csiky, M. Duane, G. Seufert (CEC-Joint Research Centre, Environment Institute, I-21020 Ispra (Va), Italy)

The oak genus, in the Fagaceae family, consists of about 450 different species world-wide. Among the many peculiar qualities, oaks are also of special interest in air chemistry, since they are emitting reactive volatile compounds. Reactive volatiles of biogenic origin are supposed to play a key role in air chemistry, e.g. affecting the OH-radical budget, the ozone and particle formation. In the US, oaks are by far the most dominant isoprene source, due to their dominant biomass and high emission rates. US inventory methods and algorithms have previously been applied for Europe. Through the findings of the BEMA-project, European inventories are modified, since many Mediterranean oaks emit high amounts of monoterpenes.
In order to get a better understanding of this surprising finding, we have performed a screening study of 10 European and 2 North-American (semi) evergreen oaks (not screened previously), to characterize the variability and evolutionary pattern of oak emissions, and to complement the BEMA field studies. We used a special minicuvette system for sampling. Chemical analysis of emitted compounds was performed using GC-FID and GC-MS. We could separate the following four emitter types: 1) strong isoprene, 2) strong monoterpenes, 3) mixed isoprene + monoterpenes, as well as 4) non-emitters. Results are discussed with respect to implications for presently used emission scenarios.

APPLICATION OF THE REGIONAL ATMOSPHERIC CHEMISTRY MECHANISM (RACM) TO THE STUDY OF BIOGENIC EMISSIONS IN THE BEMA-BURRIANA TEST-SITE

C. Cuvelier and P. Thunis (Environment Institute, Joint Research Center, Ispra, Italy)
W. R. Stockwell, M. Kuhn (IFU, Fraunhofer Institute for Atmospheric Research, Garmisch-Partenkirchen, Germany)

Due to its deleterious effect on human health, agricultural crops and forest ecosystems, tropospheric ozone continues to be of significant concern worldwide. The fundamental question to solve in environmental atmospheric chemistry is the following: "To reduce tropospheric ozone levels in impacted urban, suburban and rural areas, should one control VOC, NOx, or both simultaneously, and to what degree?". The same question holds for other air polluting compounds, such as benzene, PAN, PAH and organic particles). The potential importance of biogenic VOCs (in relation to anthropogenic VOCs) for ozone control strategies is evident from the suggestion that the BVOC emissions may be so large that even a 100 % control of AVOCs would not be sufficient to meet air quality standards.
In the present work the RACM boxmodel mechanism (developed at the IFU, Garmisch-Partenkirchen) is applied to study the influence of isoprene (hard wood), α-pinene (soft wood), limonene (citrus vegetation) and AVOC emissions on the formation of ozone and other polluting chemicals in an area that is representative for the BEMA-Burriana test-site.

TROPOSPHERIC OXIDATION OF MBO

G. Fantechi, N.R. Jensen, J. Hjorth
The European Commission, Joint Research Centre
Environment Institute, TP 272, I-21020 Ispra (VA), Italy

J. Peeters
Katholieke Universiteit Leuven, Department of Chemistry,
Celestijnenlaan 200F, 3001 Heverlee, Belgium

MBO (2-methyl-3-buten-2-ol), a C_5 unsaturated alcohol, was recently found to be an abundant volatile organic compound (VOC) of biogenic origin present in the atmosphere.
Generally, VOCs emitted from vegetation into the atmosphere are removed by reaction with atmospheric oxidants such as OH radicals, ozone and NO_3. During daylight hours, reactions with OH radicals and ozone are usually the most important removal processes, while the reaction with NO_3 can be a major sink at night.
In the present study we have attempted to identify the carbonyl products of MBO's oxidation under simulated atmospheric conditions using a 480 L Teflon coated reaction chamber coupled with a FT-IR spectrometer. Acetone was found to be among the main products.

OZONOLYTIC FORMATION OF 6-METHYL-5-HEPTEN-2-ONE AND 4-OXOPENTANAL FROM HIGH MOLECULAR WEIGHT COMPOUNDS ON LEAF SURFACES

P Fruekilde, N. R. Jensen, D Kotzias, and **B. Larsen** (EC Joint Research Centre, Ispra, Environment Institute, TP290 I-21020, Ispra(VA), Italy)

The present study explains the occurrence of 6-methyl-5-hepten-2-one in ambient air and reports for the first time the presence of 4-oxopentanal.

We have conducted a series of laboratory experiments in which it is demonstrated that significant amounts (> 10 ng/L) of 6-methyl-5-hepten-2-one and 4-oxopentanal are formed by the reaction of ozone (50-100 ppbv) with foliage of common vegetation in the Mediterranean area (Citrus > Quercus >Pinus). In order to ascertain that the formation is chemical, as opposed to biological, epicuticular waxes were extracted from the leaves, dispersed on glass wool and reacted with ozone. Again, significant amounts of 6-methyl-5-hepten-2-one and 4-oxopentanal were detected. A number of high molecular weight components were identified as potential precursors of 6-methyl-5-hepten-2-one and 4-oxopentanal by their surface reaction with ozone. The most potent of the investigated compounds were the tertraterpene squalene and the sesquiterpenes nerolidol and farnesol. The atmospheric lifetime of 6-methyl-5-hepten-2-one can be calculated from published data to approximately 1 hour at Mediterranean summer conditions. For the present study, we have synthesised 4-oxopentanal and investigated the kinetics of its gas-phase reaction with OH, NO_3 and O_3. A lifetime longer than 10 hours was calculated from the measured reaction rate constants.

MODEL INTERCOMPARISON BETWEEN THE EMEP MSC-W AND RACM ATMOSPHERIC CHEMISTRY SCHEMES

A. Gross (Danish Meteorological Institute (DMI), Meteorological and Oceanographic Research Division, Lyngbyvej 100, DK-2100 Copenhagen Ø, Denmark) W.R. Stockwell (Fraunhofer Institute for Atmospheric Environmental Research (IFU), Kreuzeckbahnstr. 19, D-82467 Garmisch-Partenkirchen, Germany)

Atmospheric transport-chemical modeling is important for understanding the impact of air-pollutant emissions, e.g. biogenic and anthropogenic, on the chemical composition of the atmosphere. Changes in the chemical composition imply consequences for the environment, e.g. changes in the concentrations of tropospheric ozone and toxic compounds as well as changes in regional depositions. The gas-phase reaction scheme is an important part of any numerical simulation of transport and transformation of trace gases.

In this paper an intercomparison of the EMEP MSC-W scheme and a recently developed chemical scheme, RACM, is presented. The schemes are used for tropospheric gas-phase chemistry research. The main difference between the RACM and EMEP MSC-W mechanisms is that the RACM mechanism has a more detailed representation of atmospheric organic chemistry.

The intercomparison is based on a series of (zero dimensional) box calculations for scenarios involving biogenic emissions and a polluted atmospheric boundary layer. The scenarios include emissions of a variety of species which are representative for continental European air. The intercomparison involves: influence of clouds on the photochemical reactions, different photochemical schemes, sensitivity analyses and uncertainty analyses.

IMPACT OF BIOGENIC VOLATILE ORGANIC COMPOUND EMISSIONS ON THE OXIDAZING CAPABILITY OF THE TROPOSPHERE: A THREE-DIMENSIONAL GLOBAL SIMULATION

D. A. Hauglustaine, G. P. Brasseur, A. Guenther and G. Bonan (National Center for Atmospheric Research, P.O. Box 3000, Boulder, CO 80307, USA)

A global three-dimensional chemical transport model, called MOZART (Model of Ozone and Related Tracers), is used to investigate the impact of biogenic emissions of volatile organic compounds (VOCs) on the budget of oxidizing species in the troposphere. The model domain covers the altitudes from the surface to the upper stratosphere with 18 vertical levels. The spatial resolution is about 2.8 degrees in latitude and longitude. Dynamical and physical fields calculated by the NCAR Community Climate Model (CCM3) are used to drive the transport of chemical species. The global distributions of 40 chemical species are calculated. The chemical scheme includes about 130 photochemical reactions

In this paper, we investigate the impact of biogenic emissions of VOCs on ozone and hydroxyl radical distributions. A special attention will be focused on isoprene and terpenes emissions. Different emission inventories of biogenic emissions are compared to site measurements and introduced in the global model. The impact of the different emission estimates on the global budget of CO is presented.

ESTIMATION OF THE ORGANIC ACID EMISSION-POTENTIAL OF A MEDITERRANEAN TREE SPECIES BASED ON ACID CONCENTRATIONS IN AND CHARACTERISTICS OF THE PLANT APOPLAST

R.Gabriel, L.Schäfer and J. Kesselmeier (Max-Planck-Institut für Chemie, Abt Biogeochemie, D-55020 Mainz, Germany)

Direct (or indirect) emission of acetic and formic acid from higher plants is regarded to be a significant source for these acids found in the the atmosphere. Considering the pathway from the plant cell to the atmosphere, a gas molecule first has to leave the liquid phase and has to reach the internal leaf gas phase. Within this context the apoplast (cell wall) is the last barrier before the molecule can escape through the stomata. Under the frame of the EU-project B.E.M.A. we followed the diel concentration patterns of apoplastic ions and organic acids in close relation to the physiological activities of *Quercus ilex L.* leaves in parallel to measurements of the emission. Concentrations in the apoplastic sap were found between 0 (not detectable) and 320 µmol/l for acetic and between 0 (not detectable) and 70 µmol/l for formic acid. Lowest concentrations were detected around noon and the highest concentrations were found in the morning and late evening. The exchange rates of acetic and formic acid followed a typical diel pattern and ranged between -10 and 52 [nmol/(m^2 min)] with the maximum around noon. We compared real emission rates with theoretical ones by calculating the theroretical emission capacity using the Henry's law constants for acetate and formate and apoplastic pH values between pH 4 and pH 5. The comparison showed that 26 to 130 % of the acetic acid emission can be explained. However, for apoplastic formic acid we found lower concentrations which may not be sufficient to explain all measured emission rates.

THE INFLUENCE OF TEMPERATURE ON BIOGENIC EMISSIONS AND OZONE CHEMISTRY

M. Hammer, **B. Vogel**, F. Fiedler and H. Vogel (Institut für Meteorologie und Klimaforschung, Forschungszentrum Karlsruhe / Universität Karlsruhe, Postfach 3640, D-76021 Karlsruhe)

Volatile organic compounds (VOC) and NO_x are the main precursors of ozone and other photooxidants in the troposphere. VOC are emitted by human activities and by plants. NO_x emissions are also caused by human activities and by microorganisms in the soil. Biogenic VOC emissions depend on the land use and on environmental conditions like temperature and the photosynthetic active radiation (PAR). The biogenic emissions of NO_x are a function of land use, surface temperature, fertilizer usage and precipitation events. The temperature dependence of the biogenic VOC and NO_x emissions is exponential and therefore it is necessary to have accurate temperature data in order to determine accurate biogenic emission data. The same is true for PAR.

Sensitivity studies of the influence of temperature on the biogenic emissions and the ozone chemistry are shown. The studies are carried out with a boxmodel, a one-dimensional and a complete three-dimensional version of the comprehensive mesoscale model system KAMM/DRAIS with the implemented RADM2 chemistry code. The results of the simulations and observations show that the temperature dependence of the ozone concentration is mostly controlled by the temperature dependence of the biogenic emissions and the thermal decomposition of PAN.

ATMOSPHERIC MEASUREMENTS OF ORGANIC TRACE GASES BY IMRMS

A.Kiendler and F.Arnold
Max Planck Institute (Atmospheric Physics Devision),
Saupfercheckweg 1, 69117 Heidelberg, Germany

Using an IMRMS (Ion Molecule Reaction Mass Spectrometer) including also a novel ion trap mass spectrometer various atmospheric trace gases were measured and feasibility studies for such measurements were made. Trace gases investigated include acetone, methylcyanide, hydrogencyanide, methanol and organic acids. Making use of the MS^N (n-th generation fragmentation studies) potential of the ion trap mass spectrometer allows the identification of mass peaks and kinetic studies of the observed ions.

CONTRIBUTION OF BIOGENIC VOC TO THE FORMATION OF OZONE IN A RURAL LOCATION IN NORTH-EASTERN GERMANY

Ralf Koppmann, Arno Wedel, and Jochen Rudolph (Institut für Atmosphärische Chemie, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany)

Atmospheric concentrations of C_6-C_{15} hydrocarbons and C_4-C_{12} oxygenated volatile organic compounds (VOC) including alkanes, aromatics, monoterpenes and aldehydes were measured during the POPCORN campaign (Photo-oxidant formation by plant-emitted compounds and OH-radicals in North-Eastern Germany) in August 1994. During this field campaign also VOC-emissions from several crop and tree species and the ambient concentrations of CO, C_2-C_7 nonmethane hydrocarbons (NMHC), light aldehydes, nitrogen oxides, ozone and hydroxyl radicals (OH) were measured. These data are used to discuss the VOC measurements.
α-Pinene and Δ3-carene, most probably originating from pine-forests about 1 km away from the measuring site, were the most abundant biogenic hydrocarbons, but in most samples also n-pentanal, n-hexanal, n-nonanal and n-undecanal were present. As emission studies indicate, these highly reactive compounds originate most probably from emissions from maize.
From the measured concentrations of methane, CO, C_2-C_{15} NMHC and C_5 - C_{11} aldehydes a photochemical production of ozone in the order of 3.5 ppb/h can be estimated by a simple first order approach. It is shown that the contribution from anthropogenic and biogenic VOC was roughly equal during POPCORN. About 20% of the ozone production can be ascribed to the turnover of monoterpenes, about 12% was due to isoprene and another 10% due to higher n-aldehydes. None of the other measured compound classes contributed more than 15%.

RELATIONSHIPS BETWEEN E/A RATIO AND MONOTERPENE EMISSIONS IN TWO EVERGREEN COMMUNITIES

Manes F., Vitale M. (Dip. di Biologia Vegetale, Università di Roma - P.le A.Moro, 5 Rome - Italy). Ciccioli P. (Ist. per l'Inquinamento Atmosferico, CNR Monte-libretti, Rome - Italy). Seufert G. (Environment Institute, JRC Ispra (VA) - Italy)

Within the frame of the Biogenic Emissions in the Mediterranean Area project aimed at assessing the emission of volatile organic compounds from Mediterranean plant species, a work was performed in which ecophysiological data were collected with single-leaf cuvettes in the field. These data are useful for: 1) extrapolating data to the entire canopy through up-scaling processes; 2) assessing whether data collected could have been used to get emission figures that were representative of the different physiological situations experienced by the plant in our sites. Gas-exchange measurements were performed in May on *Quercus ilex* L. and *Pinus Pineu* L. growing into oak-pine forest in Castelporziano (Italy) and *Citrus sinensis* (L.) Osbeck placed in a orange grove in Burriana (Spain). Very important are the net photosynthesis (A) and leaf transpiration (E) because these parameters are related to the amount of VOC produced by the plant and released in the air measured by cuvette method. For this reason, the value between the water transpirated and the carbon assimilated (E/A) seems a useful index for better understanding the emission process related to plant species and environmental parameters. Comparing the E/A ratio and monoterpenes emission values in the various ecosystems we observe a strong correlation between these parameters, suggesting the possibility to describe the two evergreen communities on the basis of functional characters.

ESTIMATIONS OF BIOGENIC VOC EMISSIONS FROM A NORTHERN BOREAL FOREST USING THE MICROMETEOROLOGICAL GRADIENT METHOD

J.Rinne, M.Aurela, H.Hakola & T.Laurila.
Finnish Meteorological Institute, Air Quality Research
Sahaajankatu 20 E, FIN-00810 Helsinki, Finland
janne.rinne@fmi.fi

Forests in the boreal regions are assumed to be a major source of volatile organic compounds (VOCs). Important hydrocarbon species emitted by vegetation include isoprene and monoterpenes. As a part of the BIPHOREP-project, aimed to quantify biogenic VOC emissions and photochemistry in the boreal regions of Europe, we have conducted a measurement campaign in northern boreal zone near the Pallas-Ounastunturi National Park in Finland in July 1996. Forest in the measurement site (67°58'N, 24°14'E) was composed mainly of mountain birch, norway spruce and scots pine. Vertical gradients of VOCs were measured above the forest canopy. Light hydrocarbons were sampled in steel canisters via teflon tubing from 19 and 31 metres and terpenes were sampled on the same heights in Tenax-tubes using automated samplers. Turbulent exchange coefficients are derived from eddy covariance fluxes using Businger-Dyer-equations. We present vertical fluxes calculated from the measurements. Error sources and estimations of the accuracy of the calculated fluxes are discussed. Temperature dependence of the emissions is also shown. The data suggests that also other environmental parameters have some effect on the emissions.

THE BEMA-PROJECT: SCALING UP THE BIOGENIC EMISSIONS FROM TEST SITES TO LANDSCAPES

R.J.M. Lenz (FH Nuertingen, Schelmenwasen 4-8, D-72622 Nuertingen, Germany) G. Schaab. M. Sharma (GSF Research Centre for Environment and Health, P.O. Box 1129, D-85758 Oberschleissheim, Germany)

On the basis of measurements of emission rates, Leaf Area Indices (LAI) and biometric data for about 20 species and 15 land-cover types, a scaling up of biogenic emissions is presented. It includes the application of different procedures for scaling up, by combining parameters (e.g. LAI, biomass, vegetation coverage, canopy layering, insolation) with emission rates and algorithms in a spatial model. This approach consists of the following steps: (i) elaboration of a pseudo-three dimensional Geographical Information System (GIS) for the test sites in Italy, France and Spain, (ii) calculations of relations between diameter at breast height (dbh), biomass and LAI, (iii) application of an insolation and light interception model in the stands for one to two canopy layers and surfaces, (iv) based on emission rates for pine, holm oak and orange trees as well as standardized emission factors for light, classified incoming light is driving the diurnal and seasonal course of emissions for the test sites. Calculations of total emission fluxes are intercompared according to the different formulas and parameter combinations, e.g. the relevancy of spatial effects. Some results of the GIS model for insolation and light interception are shown to strengthen its usefullness in sparse vegetation and complex terrain.

THE INFLUENCE OF SOLAR UV-B RADIATION AND DROUGHT STRESS ON THE EMISSION RATE AND CONTENT OF TERPENES OF NORWAY SPRUCE NEEDLES (PICEA ABIES L. [KARST.])

H. Panten and R. Steinbrecher (Fraunhofer Institut Atmosphaerische Umweltforschung (IFU), Kreuzeckbahnstr. 19, 82467 Garmisch-Partenkirchen, Germany)

The essentials of biogenic production and emission of terpenes of Picea abies have been studied very well. It is known that several environmental and genetic factors influence the content and emission rate of these biogenic volatile organic compounds (BioVOC). Nowadays climatic changes and an increase of UV-B radiation have been predicted. A feedback of changed climatic factors in combination with an enhanced UV-B radiation can not be excluded. Further investigations have to be done to update the role of BioVOC concerning tropospheric chemistry and plant physiology in view of global change processes. To test the effects of solar UV-B radiation in combination with drought stress, 4-year old clonal Norway spruce trees were investigated in a study designed as UV-B exclosure experiment. The experiment was carried out at 710 m above sealevel in Garmisch-Partenkirchen in 1995 and 1996. The spruce trees were cultivated in ventilated plant chambers equipped with UV-B transmittable plexiglas. Two variants (UV-B exclosure conditions and +UV-B=20conditions) were realized by using two types of plastic films differing in their UV-B transmittance. During the exposure time of 22 weeks UV-B radiation, as well as the climatic parameters air temperature, air humidity and soil water potential were monitored. Effects of UV-B radiation and drought stress were studied on the levels of photosynthetic gas exchange, terpene emission and monoterpene content of current-year spruce needles.

EMISSIONS OF VOLATILE ORGANIC COMPOUNDS FROM AGRICULTURALLY USED VEGETATION: AMBIENT MEASUREMENTS, FIELD STUDIES OF EMISSIONS AND LABORATORY INVESTIGATIONS

J. Rudolph A. Wedel
Institut fuer Atmosphärische Chemie (Forschungszentrum Jülich GmbH, D-52425 Jülich, Germany, E-mail: J.RUDOLPH@KFA-JUELICH.DE)
G. Schuh A. Heiden and J. Wildt (Institut fuer die Chemie der belasteten Atmosphaere, Forschungszentrum Jülich GmbH, D-52425 Juelich, Germany)

There are large areas with agricultural crops as essentially the only vegetation. For many of these areas industrial or urban emissions are low. Atmospheric VOC chemistry over these regions may thus be dominated by emissions from the crops. However, our present knowledge of VOC emission rates from agriculturally used plants is very limited. In this study a brief overview of the emissions of VOC from vegetation will be given and results from several studies we recently conducted will be presented. These studies include laboratory studies in a controlled environment chamber under defined conditions, field studies with a mobile flow-through plant enclosure and ambient measurements above a corn field. The results show that the emission rates of VOC from agriculturally used plants under normal conditions are low, in most cases at the lower end of published emission rates. The emitted VOC are a complex mixture of various types of compounds, including a number of oxygenated substances. Higher emission rates are found under specific conditions, e.g. during flowering, but also stress of various types strongly enhances the VOC emission rates. An ambient study in a rural area of Central Europe showed that in spite of relatively low emission rates roughly 50% of the photochemical ozone production can be ascribed to VOC emitted from vegetation.

DIURNAL AND SEASONAL VARIATION OF THE EXCHANGE OF SHORT CHAINED ORGANIC ACIDS AND ALDEHYDES BETWEEN TWO MEDITERRANEAN TREE SPECIES (HOLM OAK, *Quercus ilex*; PINE, *Pinus pinea*) AND THE ATMOSPHERE

L. Schäfer, R. Gabriel, H. Müller, A. Wolf and J. Kesselmeier (Max -Planck-Institut für Chemie, Abt Biogeochemie,Johann-Joachim Becher Weg 27, D-55128 Mainz, Germany)

Within the frame of the EU-project B.E.M.A. we investigate the emissions of formic acid, acetic acid, formaldehyde and acetaldehyde from Mediterranean vegetation to the atmosphere. Within joint field measurements have we explored two typical Mediterranean tree species, Holm oak (*Quercus ilex*) and pine (*Pinus pinea*) at Castelporziano (Rome/Italy), using a dynamic cuvette system flushed with ambient air. We followed the diel emission pattern and the plant's physiological activities in spring, summer and autumn. Emission measurements under the diurnal light/dark cycle showed correlations between the release of acids and light intensity, leaf temperature and transpiration of an enclosed branch but only poor correlations between the aldehyde exchange and physiological behaviour. The results suggest a direct emission from the vegetation for the acids and probably a bidirectional exchange for the aldehydes. The exchange rates of the compounds followed a diurnal as well as a seasonal pattern with maxima at noon and in the summer and ranged between -0,052 - 0,37 [nmol/(g d.w · min)] for organic acids and between -0,4 - 1,2 [nmol/(g d.w. · min)] for aldehydes. The direct emission of both organic acid species from the vegetation seems to be a significant source for the organic acid budget in the atmosphere.

AN ALGORITHM FOR THE DETERMINATION OF EMISSION RATES OF TERPENES FROM SUNFLOWER AND OTHER PLANTS

G. Schuh, J. Wildt, D. Kley (Institut für Chemie der Belasteten Atmosphäre, ICG-2), P.Rockel (Institut für Biotechnologie, IBT-3)
J. Rudolph (Institut für Atmosphärische Chemie, ICG-3)
Forschungszentrum Jülich, Leo-Brandt-Str., D-52425 Jülich; Germany

Emissions of volatile organic compounds from sunflower *(Helianthus annuus)* were measured in a continuously stirred tank reactor. The emission rates of isoprene, α-pinene, sabinene, limonene, an unidentified compound and the sesquiterpene caryophyllene were dependent on temperature as well as on light intensity. During darkness significant emission rates of monoterpenes were observed, too. The behaviour of the terpene emission rates with temperature and light intensity can be described by an algorithm that combines the model for the emissions originating from a pool and its temperature dependence *(Tingey et al.1991; in Trace gas emissions by plants, Acad.Press)* and the algorithm given by *Guenther et al. 1993(J.Geoph.Res.98,12609)* after a slight modification.

SOURCES AND SINKS OF TERPENOIDS IN FORESTS: CAMPARISON OF FLUXES MEASURED BY ZERO AIR ENCLOSURES AND BY MICROMETEOROLOGICAL METHODS

G. Seufert (CEC-JRC, Environment Institute, I 21020 Ispra (Va), Italy
R. Valentini (Univ. Tuscia, Via S. Camillo de Lellis, I-01100 Viterbo, Italy)
P. Ciccioli (CNR-IIA, Via Salaria km 29.200, I-00016 Monterotondo Scalo, Italy)

Biogenic emissions of volatile organic compounds play a key role in atmospheric chemistry and ozone formation. In the frame of the BEMA-project on "Biogenic Emissions in the Mediterranean Area" we realized that very fast reacting terpenoids are among the most abundant compounds emitted from some ecosystems. We estimated the diurnal course of potential emission fluxes with six zero air enclosure systems installed on representative branches and on the soil. The real terpenoid fluxes above the canopy were analyzed simultaneously with relaxed eddy accumulation and gradient measurements from a tower. In case of a forest dominated by Umbrella pine (t-β–ocimene, linalool), and of a Citrus orchard during (linalool) as well as outside the flowering period (β-caryophyllene) only a few percent of the major compounds emitted could be observed as a flux above the canopy. The soil represented a major source of limonene in both ecosystems. Fluxes of more stable compounds like α–pinene or limonene indicated agreement of the three measuring techniques to within 25% and a promising suitability of our method to develope a general sink function, describing the within canopy removal of reactive terpenoids due to chemical transformation and/or deposition. Completing the budget would require strong efforts in analyzing the within canopy transport, chemistry and deposition, and the formation of reaction products like organic aerosols.

A New Mechanism for Regional Atmospheric Chemistry Modeling

William R. Stockwell (Fraunhofer Institut für Atmosphärische Umweltforschung IFU, Kreuzeckbahnstr. 19, D-82467 Garmisch-Partenkirchen, Germany)
F. Kirchner (Aristotle University Thessaloniki, GR-54006 Thessaloniki, Greece)
M.Kuhn (IFU) and St. Seefeld (EAWAG, CH-8600 Dübendorf, Switzerland

We will present a new atmospheric chemical mechanism for the modeling of regional air pollution, the "Regional Atmospheric Chemistry Mechanism" (RACM). Ozone is produced through the photo-oxidation of nitrogen oxides and volatile organic compounds including important biogenic emissions like isoprene and terpenes. Since the organic chemistry of the atmosphere is very complicated and computer resources are limited, the RACM mechanism uses grouped organic classes to describe atmospheric organic chemistry. The individual emitted organic species are aggregated into the 31 RACM classes through a reactivity weighting approach. The organic chemistry of the RACM mechanism is a significant improvement over existing mechanisms. The oxidation schemes of alkanes, alkenes and aromatics were reevaluated and improved through the use of new laboratory data. Biogenic species explicitely handled in RACM are isoprene, alpha-pinene and d-limonene. The new isoprene scheme includes an improved representation of methacrolein, isoprene ozonolysis, hydroperoxide production and the carbonitrate production. The peroxyacetyl nitrate chemistry and the organic peroxy radical - peroxy radical reactions were revised which caused a significant reduction in predicted PAN concentrations. The new RACM mechanism has been tested against smog chamber data. Predicted ozone profiles and the timing of the ozone peak are well within the uncertainties of experiments.

STUDY OF THE ROLE OF BIOGENIC EMISSIONS THROUGH 2-D PHOTOCHEMICAL NUMERICAL SIMULATIONS

P. Thunis and C. Cuvelier (Environment Institute, Joint Research Center, Ispra, Italy)

In the general battle against air pollution, a fundamental question is to know whether a reduction of VOC or NOx emissions is the more adequate to reduce ozone concentrations. The term VOC encompasses biogenic (BVOC) and anthropogenic (AVOC) compounds and it is known that the biogenic fraction may be a significant contributor to ozone production/destruction processes due to its high reactivity. By neglecting BVOC, previous investigators may have overestimated the effectiveness of ozone abatement strategies based on reducing AVOC emissions. In the present work, this important problem is studied via numerical simulations by using a coupled mesoscale meteo-photochemical model (TVM-LCC). TVM-LCC is a nonhydrostatic incompressible mesoscale model written in vorticity, including prognostic equations for 35 species involved in 120 gas-phase chemical reactions. An idealised coastal geography representative of the Mediterranean area is selected to produce bidimensional emission scenarios. Those scenarios are designed to quantify the relative importance of various factors that may potentially affect ozone formation: strength and type of emissions, influence of the relative location of anthropogenic and biogenic emission sources, time and duration of these emissions,... For those various cases, the impact of biogenic emissions is investigated over the whole planetary boundary layer

DIFFERENCES IN THE OZONE PRODUCTION CAUSED BY TWO ISPOPRENE SCHEMES

H. Vogel, F. Fiedler, B. Vogel and M. Hammer (Institut für Meteorologie und Klimaforschung, Forschungszentrum Karlsruhe / Universität Karlsruhe, Postfach 3640, D-76021 Karlsruhe)

Many studies have shown the importance of biogenic emissions concerning ozone production. In order to quantify the portion of the biogenic emissions, it is necessary to know the horizontal distribution of landuse, temperature and photosynthetic active radiation in detail. The chemical reactions of the species emitted by plants have to be treated with sufficient accuracy to quantify the contribution of the biogenic emissions on photochemical ozone production. With the comprehensive mesoscale model system KAMM/DRAIS the biogenic emissions are determined for a summer smog episode occuring in the upper Rhine valley. The implemented chemistry code RADM2 was improved with the isoprene chemistry of Zimmermann and Poppe (1996). Model simulations with a one-dimensional version and the comprehensive threedimensional modellsystem show the influence of the different isoprene schemes on the ozone production. The results show that the differences between the various reaction schemes depend on the concentration levels.

MEASUREMENTS OF VOC-EMISSIONS FROM AGRICULTURALLY USED PLANTS IN GERMANY

Arno Wedel, Franz-Josef Johnen, Ralf Koppmann, and Jochen Rudolph (Institut für Atmosphärische Chemie, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany)

Plant emissions are thought to contribute substantially to the VOC budget in the troposphere. Up to now only few emission studies have been performed on agriculturally used plants in central Europe.
In spring and summer of the year 1995 we investigated the emissions of C_5-C_{15} hydrocarbons and C_4-C_{12} oxygenated volatile organic compounds (VOC) from wheat, rye, barley, potatoes, maize, rape, and sunflowers on farm-land in Germany. For these studies we used a mobile plant enclosure system with clean air supply. In order to avoid stress effects during the experiments CO_2 and temperature levels inside the chamber were adjusted to the ambient values. The relative humidity in the chamber was kept below 65% all the time. Air samples were collected on adsorption tubes and analysed in the laboratory using a GC-MS/FID-System.
Blossoming sunflowers showed emissions of up to 12.5 µg/h*g (dry weight) α-pinene and 9 µg/h*g sabinene on hot and sunny days. These values are on the upper end of the VOC-emissions from plants reported in the literature so far. In contrast to the light and temperature dependence of plant emissions reported in the literature, the emission rates reached their diurnal maxima several hours before the temperature and radiation maxima were reached. For all other investigated species and substances the emission rates were close to the experimental detection limit (<50 ng/h*g for most compounds) or not measureable at all. Thus they were on the lower end of previous measurements and estimations.

PLANETARY AND SPACE SCIENCE (PS)

PS1 Planetary interiors

Convener: Lognonné, P.
Co-Convener: Gudkova, T.V.

Temperature at the core-mantle boundary (CMB) as a control variable in modelling planetary dynamics

Arie van den Berg, Dept of Theoretical Geophysics, Univ Utrecht, TA-3508 Utrecht, The Netherlands.
David A. Yuen, Dept. of Geology and Geophysics and Minnesota Supercomputer Institute, Univ Minnesota, Minneapolis, MN 55415-1227, U.S.A.

In planetary convection there has been great emphasis laid on the usage of dimensionless parameters, such as the Rayleigh and dissipation numbers. However, the complicated rheology and equation of state parameters in mantle properties has made it increasingly difficult to study the effects of varying influences, such as changing the Rayleigh number and not changing the rheological law in the process. We have adopted the approach of using as the sole control variable the tempera- ture at the CMB, T-cmb ,in modelling mantle dynamics with a composite non-Newtonian and Newtonian rheology, which is temperature- dependent in the upper mantle and temperature- and pressure- dependent in the lower mantle. We have obtained scaling results for the physical quantities such as velocity, surface heat flow with T-cmb, which is useful for understanding thermal evolution with variable viscosity. Viscous heating is found to increase with the T-cmb , as is the tendency for shear deformation to develop along descending limbs in convection.

CONSTRAINTS ON MARTIAN MANTLE STRUCTURE FROM CONVECTION RESULTS WITH PHASE TRANSITIONS

D. Breuer and D. A. Yuen (Minnesota Supercomputer Institute and Department of Geology and Geophysics, Minneapolis, MN 55415, U.S.A.)
T. Spohn (Institut für Planetologie, Wilhelm-Klemm-Str. 10, 48149 Münster Germany)

The exothermic phase transitions, olivine to β-spinel and β- to γ-spinel, may modify the Martian convection structure and cause partial layering. An extended Boussinesq approximation has been used for an axisymmetric spherical-shell and a 3-d model in which latent heat effects are included. The time-series of the mean vertical mass transport across the phase transitions show oscillations between blocking and acceleration of the flow which is caused by two opposing effects: the enhanced buoyancy due to the phase boundaries by thermal anomalies and the impeding influences of the latent heat. The effect of the latent heat is stronger in Mars as compared with the Earth because of the comparatively low pressure gradient in the Martian mantle and the smaller excess temperature of up- and downwellings relatively to the surrounding mantle. We have also considered a model with the endothermic spinel to perovskite transition. Here, the upwellings are weaker with a smaller excess temperature and the convection flow is more sluggish as compared to the model without endothermic phase transition. Consequences of the partial layering could be a strong time dependence of the Martian volcanic activity and a relatively hot lower mantle. Implications for the thermal evolution are that with the temporal and partial blocking of the flow the planet will cool slower and less uniformly.

THERMODYNAMICS OF $MG_{1-X}FE_XSIO_3$ PEROVSKITE AND PROPERTIES OF THE MANTLE

N.Ya. Bubnova, A.A. Kalachnikov, and V.L. Pankov and **N.Ya. Bubnova** (United Institute of Physics of the Earth, Russian Academy of Sciences, Bol'shaya Gruzinskaya 10, Moscow, 123810, Russia)

The combined compression data of Knittle and Jeanloz (1987) and Mao et al (1991) were analyzed by the Zharkov-Kalinin method to find the equation of state (EOS) of silicate perovskite (Pv) presumably dominating in the lower mantle. The total set of the 2nd- and 3rd-order parameters, including bulk modulus, thermal expansivity, heat capacity, Gruneisen parameter, and their P-T derivatives, was calculated at various P-T conditions. The optimal parameter values for the Pv with density of 4.225 at normal conditions are K = 2.536, dK/dP = 4.69, gamma = 2.0, q = 0.65, and theta (Debye temperature) = 1000 K. Specific features of the thermodynamic behavior of Pv are discussed. It is shown that the Pv EOS satisfies the Birch and Anderson laws of corresponding states, the fact helping to compare the mineral properties with seismic data. The Pv EOS agrees with seismic models of the lower mantle, suggesting the mantle to consist only of perovskite with about 2-2.6 at

A VERY BROAD BAND 3 AXIS SEISMOMETER FOR STUDYING INTERNAL STRUCTURE OF SOLAR TELLURIC PLANETS

S. Cacho[1], P. Lognonné[1], J.F. Karczewski[2], J. Gagnepain-Beyneix[1], C. Cavoit[3], N. Striebig[2], B. Brient[2], A. Desautez[2] (1: IPGP, Paris, France, 2: INSU/DT, Saint Maur, France, 3: CRG, Garchy, France).

Very Broad Band seismometers are the best instruments for studying internal structure of planets like Mars, but also satellites like Moon.
Measurement of ground acceleration in three privileged directions, permits to inform us on seismic activity of a planet and therefore on its structure.
Such instrument, space qualified, must be highly sensitive in a bandwidth from 10^{-3} Hz to 10 Hz, where seismic signal is expected. High sensitivity is absolutely necessary for resolving low seismic activity of bodies like Mars and Moon.
We developed a such instrument, all titanium, where mechanisms and electronics have been designed to reach a low instrumental noise and therefore a high sensitivity. A first mock-up was recently made, giving us first results. We obtained a Q factor of the suspension close to 1000 and a M.Q.T product upper 15. The brownian noise of the pendulum is lower than 10^{-10} m.s^{-2}/√Hz; sensitivity is about 5000 V.s/m in a bandwidth from $2.8.10^{-3}$ Hz to 40 Hz.
Tests are still in progress, but they have already shown the high quality of the instrument made.
This seismometer have been designed to be insensitive to environment parameters like temperature, pressure, local gravity...
Mass is lower than 1 kg; 3.5 kg are found including deployment and installing system. The aggregate take place in a cylinder of 17 cm diameter, 20 cm height. Total power consumption is lower than 500 mW. All have been designed to support a landing shock of 350 g - 15 ms.
This instrument will be proposed for future Martian or Lunar explorations.

ON THE CORE MASS OF THE ASTEROID VESTA.

G. Dreibus and H. Wänke (MPI für Chemie, Saarstr. 23, D-55122 Mainz)

The recent images of Vesta from the Hubble Space Telescope gave a new value for its diameter and density.
Since about twenty years Vesta has been proposed as the parent body of howardites, eucrites, and diogenites (HED-meteorites) because of the similar reflectance spectra of Vesta and the basaltic achondrites. In 1980 we determined the chemical composition of the silicate phase of the EPB(= eucrite parent body) for which a FeO concentration of 14.8 % and a Fe/Si ratio of 0.53 was obtained. Assuming an equilibrium between silicate and metal during the formation of the asteroid Vesta and using experimental metal-silicate-partition coefficients for various elements core masses between 50% and 10% are reported in the literature. Here we use the straightforward assumption that the asteroid contains Fe and Ni in CI abundances relative to Si. It is further assumed that the portion of Fe not contained as FeO in the mantle as well as all Ni is present in elemental state in the core. In this way a core mass of 21.7 % is obtained. As the abundances of moderately volatile elements in the EPB(=Vesta)-mantle are ≤ 0.08, at least the same depletion could be expected for sulfur, which therefore must be very low in the core. Our mantle composition and the derived mantle mineralogy leads to a mantle density of 3.4 g/cm^3. With a core density of 7.9 g/cm^3 and our core mass fraction of 21.7 % we obtain for the mean density of Vesta a value of 3.8 g/cm^3 which is well within the range obtained by astronomical observations. With a diameter of 525 km for Vesta the 21.7 % core mass corresponds to a core radius of 123 km.

THERMAL CONVECTION IN A VOLUMETRICALLY HEATED FLUID WITH TEMPERATURE-DEPENDENT VISCOSITY: IMPLICATIONS FOR PLANETARY THERMAL EVOLUTION.

O Grasset (Lab. Physique Planetologie,rue de la Houssiniere,44072 Nantes, France)
E.M Parmentier (Geol Dpt box 1846,Brown Univ.,Providence RI, 02912, USA)

Terrestrial planets are composed of a conducting lithosphere overlaying a convecting mantle and a core. Parameterized models studying thermal evolution of these planets are usually based on the assumption that the lithosphere - convecting mantle boundary can be defined by an isotherm below which viscosity can be considered infinite on geologic time scales. Nonetheless, recent experimental results of Davaille and Jaupart (1993) are a strong argument against this assumption.
We have investigated the definition of the lithosphere - convecting mantle boundary using a thermal convection model for an infinite Prandtl number volumetrically heated fluid with a strongly temperature dependent viscosity. For very high viscosity contrast, a penalty function finite element formulation with direct inversion solver has been used. At high viscosity contrast, a conductive lid regime appears. Convection is located below a stagnant lid and is only driven by a temperature contrast depending on the rheological law of the fluid and on the interior temperature. This result, in good agreement with experimental studies of Davaille and Jaupart (1993), indicates that transition between the lid and the convecting layer (similar to the Lithosphere-mantle boundary) cannot be defined as a simple isotherm. During thermal history of planets, it is the viscosity contrast in the convecting region which remains constant, but not the temperature at the bottom of the lithosphere. Applications of these results to thermal planetary evolution models will be presented

MODELS OF JUPITER AND SATURN WITH THE ATMOSPHERE ENRICHED AND DEPLETED BY WATER

T.V.Gudkova, V.N.Zharkov (Institute of Earth Physics, B.Gruzinskaya, 10, 123810 Moscow, Russia)

New models of interior structure of Jupiter were constructed using the new data of "Galileo". The new estimation of the oxygen content in the Jupiter's atmosphere is 0.2 of solar value. This value is not in agreement with the data of Shoemaker-Levy impact analysis (10 solar values). Taking into account the both estimations, the models, enriched and depleted by water, were calculated. The test models of Saturn with the atmosphere depleted by water were also considered. Considering that the pressure of the transition of molecular hydrogen into metallic state depends on the temperature and the amount of metallic impurities of ice-rock component in the molecular envelope, three values of pressure 3, 2 and 1.5 Mbar were used. Due to the fact that internal molecular layer of Saturn is enriched by IR component 3–4 times more than Jupiter's one, the pressure of the molecular-metallic hydrogen transition could be less in Saturn. The mass of the hydrogen-helium component lost under the formation of the planets is about 2–5 planetary masses for Jupiter and 11–14 for Saturn.

INTERIOR STRUCTURE MODELS OF MARS

T.V.Gudkova (Joint Institute of Earth Physics. B.Gruzinskaya. 10, 123810 Moscow, Russia)
F.Sohl (Institut für Planetologie, Wilhelm Klemm-Str.10, D-48149 Münster,Germany)

Martian interior structure models combined with detailed crust models calculated by *Babeiko et al.*(Solar System Research,1993,27.149) using the approach of thermodynamic modelling are presented. The crust thickness is varied from 50 to 150 km and the possibility of a depleted upper mantle is investigated. Hydrostatic equilibrium and stationary heat transfer are assumed and the basic differential equations for the mechanical and thermal structure are solved numerically together with an isothermal Murnaghan–Birch type equation of state. STP–values of density, bulk modulus, and thermal expansivity for core and mantle materials are calculated from laboratory data for the specific SNC chemistry. In our models the Fe-Ni–FeS core contains some amount of hydrogen. The recent data on the behavior of FeS and FeH at high pressures and temperatures are used. The influence of hydrogen on the physical constitution of Fe-Ni–FeS core suggested by the analysis of SNC meteorites and the presence of the perovskite layer is discussed.

EARTH'S CORE: COMPOSITION, TEMPERATURE, AND EQUATIONS OF STATE

T.V. Ivanova, A.A. Kalachnikov, and V.L. Pankov and **T.V. Ivanova** (United Institute of Physics of the Earth, Russian Academy of Sciences, Bol'shaya Gruzinskaya 10, Moscow, 123810, Russia)

Equations of state (EOS) of FeO (hpp), FeS (hpp), Fe (g, e, and liquid phases), and Ni were determined from experimental data by the Zharkov–Kalinin potential method and used to evaluate the composition, temperature, and properties of the Earth's core through comparison with the standard density and bulk sound velocity distributions in the core. For three-component models (Fe+FeO or Fe+FeS, with a fixed Ni content), the component concentrations and temperature distribution are derived, considering the equation for the critical (convective) temperature gradient in the core. For four-component models (FeO+FeS+Fe+Ni), the composition is calculated at a given temperature in the core. Our preferred models are found to contain (wtand 0-52 FeO, 0-38 FeS, and 42-72 Fe in the outer core. All of the three-component models result in a high temperature of the core, varying from 4800-5500 K at the core-mantle boundary to 5600-7000 K at the inner core boundary. The results obtained are discussed in the context of available phase relations for the core mineral systems.

CONSTRAINING THE MEAN TEMPERATURE OF THE MANTLE OF MARS USING THE SECULAR ACCELERATION OF PHOBOS

A. Mocquet, O. Grasset and C. Sotin (Laboratoire de Géophysique et Planétologie, Faculté des Sciences et Techniques, 2 rue de la Houssinière, BP 92208, 44322 Nantes Cedex 3, France; e-mail: mocquet@chimie.univ-nantes.fr)

The tides of Mars induced by the secular acceleration of Phobos provide a constraint on the rheological and thermal properties of the planet through the frequency dependent product k_2/Q, where k_2 is the tidal Love number, and $1/Q$ is the dissipation function. The value of k_2 is primarily sensitive to the radius of the martian core and, to a lesser extent, to the composition of the mantle. The dissipation function is primarily governed by temperature. Averaged temperature profiles of the mantle are tested against the constraint $k_2/Q \sim [1.834 \pm 0.061 (2\sigma)] \times 10^{-3}$, for different values of core radii. A temperature gradient of the order of 4.5 K/km is assigned to the lithosphere over a thickness of a few hundred kilometers. This thermal conductive layer is followed at greater depth by a quasi-isothermal mantle, the temperature of which is varied between 1000K and 2000K among the different models. Mineralogical models corresponding to these different thermodynamical conditions are constructed under the assumptions of either an Earth-like composition or an iron-rich composition of the mantle. The rheological properties of the models are computed using Grüneisen's and third-order finite strain theories, together with mineral physics data compiled after high pressure and high temperature experiments. Finally, Love numbers and dissipation functions are evaluated and compared to the measured value.

MARS: THE 3D-PLANFORM OF THERMAL CONVECTION AND ITS RELATION TO DEEP MANTLE STRUCTURE

H. Harder (Institut für Geophysik, Göttingen, D-37075 Germany)

The presence of the phase transition to perovskite at the base of the Martian mantle enforces an evolution of the mantle flow towards a one-plume structure (Harder and Christensen, 1996). Here these earlier results are extended by considering several aspects of potential importance for the Martian mantle flow: non-Boussinesq-effects, the presence of additional phase transitions in the spinel field and the influence of decaying heat sources.
In a set of axisymmetrical simulations the extented Boussinesq appoximation is employed in order to estimate the relative importance of latent heat effects, viscous dissipation and adiabatic decompression. The results demonstrate that important simplifications are possible due to the small dissipation number of the Martian mantle.
An additional set of 3D-models includes also the effect of decaying heat sources of the planet. A simplified time evolution of the Martian mantle flow is calculated and compared with the history of volcanism on Mars and the the present shape of the geoid.
H.Harder and U. Christensen, A one-plume model of martian mantle convection, Nature, 380, 507-509, 1996

ELASTIC PROPERTIES OF MAGNESIUM SILICATE PEROVSKITE, MAGNESIUM OXIDE AND SILICA AT LOWER MANTLE PRESSURES

Bijaya B. Karki and Jason Crain (Department of Physics and Astronomy, The University of Edinburgh, Edinburgh, EH9 3JZ, Scotland, UK)

High-pressure structural properties, including phase transitions, of three minerals, $MgSiO_3$ perovskite, MgO and SiO_2, are studied using first-principles computer simulations based on the plane wave pseudopotential method. Determination of the full elastic constant tensors of the minerals suggests that the elastic wave velocities and anisotropy are strongly pressure dependent. Comparisons of the predicted elastic properties and densities of the minerals with the seismic properties supports a Mg-rich silicate perovskite-dominated lower mantle composition.

USING THE NIMS OF THE GALILEO SPACECRAFT TO STUDY POSSIBLE THERMAL SPOTS AND LINES ON THE SURFACE OF EUROPA

Antonio de Morais, Institute of Physics. University of Sao Paulo, Brasil

The Near-Infrared Mapping Spectrometer (NIMS) of the NASA Jet Propulsion Laboratory's Galileo spacecraft is being used to study the atmospheric and surface composition of Jupiter and its satellites. Here in this paper, I propose the NIMS to be used to look for possible thermal spots and lines on the surface of Europa, a Jupiter's moon. Those thermal features might be related to surface places where the Europa's internal heat (due to the gravitational tidal heating by Jupiter) is being necessarily put off, carrying up by convection material from deep regions. And, perhaps, it is possible that those thermal features be related to or even match the brownish spots, lines and cracked ice plates which crisscross the surface of Europa as appeared in the Voyagers' and Galileo's photographs. Thus, studying the spectroscopic signatures of substances present in those thermal places, and also taking the influence of the ice cap plates' pressure into the chemical reaction rates, it will give information about the sub-surface composition and dynamics, including possible biological-related chemical reactions. Here I also propose a simple model for Europa's interior, based on the density of Europa (2.97 g/cm3): In Galileo's photographs appear the image of ancient impact craters, and so this means that global resurfacting by internal material had probably took place long ago. And the probability of a present Europa with a subsurface global water ocean, is not great In my view, Europa would probably have some connected small and great deep water lakes, located almost totally at Europa's region facing Jupiter, equatorially-symmetric distributed, and arranged differentially in diverse profoundnesses. And at the face opposed to Jupiter, small and very deep water lakes, kept by central radioactive source within a pressure-modified mixture of water ice and silicates forming the Europa's rocky core. Galileo spacecraft could also be used to measure the gravitational field of Europa to give more information about its interior.

THE BULK CHEMICAL COMPOSITION OF MARS

Chrystèle SANLOUP[1], Albert JAMBON[2] and Philippe GILLET[1].
[1]Laboratoire des Sciences de la Terre, ENS-Lyon, Lyon, France
[2]Laboratoire MAGIE, Université Paris VI, Paris, France

According to the composition of SNC meteorites, inferences on the chemical composition of the Mars can be proposed. Additional constraints are provided by the planet bulk density and the size of its core. Despite the fractionated character of SNC meteorites relative to the bulk composition of its parent body, comparison with other objects of the solar system including chondrites and other planetary bodies (especially the Earth) point out to one major characteristics of the martian mantle, i.e. its high Fe abundance when compared to the terrestrial mantle, which can be translated in terms of a lower Fe/(Fe+FeO) ratio. A review of compositional models proposed previously reveals a number of unnecessary hypotheses, i.e. not substantiated by SNC compositions. We propose a new model of chondritic composition which takes into account the largest number of constraints considered so far and the minimal number of hypotheses. This bulk composition can be used to infer possible scenarios of Mars differentiation in accordance with the composition of SNC. It can also be used as a starting point for exploring possible mineralogical models of the martian mantle.

PS2 Evolution and state of surfaces, crusts and lithospheres of planetary bodies

01 Venus: the emerging understanding of Earth's sister planet

Convener: Saunders, R.S.
Co-Convener: Raitala, J.

Sponsorship: IUGS-CCP (International Union of Geological Sciences Commission on Comparative Planetology)

1:10M GEOLOGIC MAPPING OF NORTHERN VENUS

A.T. Basilevsky, N.N. Bobina, G.A. Burba, M.A. Ivanov, V.P. Kryuchkov, A.A. Pronin, V.P. Shashkina (Vernadsky Institute, 117975 Moscow Russia)
J.W. Head (Geological Dept., Brown University, Providence R.I. 02912 USA)

Based on photogeologic analysis of the Magellan images 1:10M geologic mapping of Venus northward of 35oN has been done. The mapping results are presented in the form of six separate sheets in polar azimuthal projection. The mapped rock-stratigraphic units include (from older to younger): 1) Tessera materials; 2) Materials of densely fractured plains; 3) Materials of fractured and ridged plains and ridge belts; 4) Materials of shield plains; 5) Materials of plains with wrinkle ridges; 6) Materials of lobate and smooth plains; 6) Materials of dark parabolas. Some units are subdivided into subunits whose amount may differ on different sheets. For some units covering relatively large areas impact crater densities were determined.

VENUS SURFACE PROCESSES: RESULTS FROM MAGELLAN AND QUESTIONS FOR FUTURE EXPLORATION

Bruce A. Campbell (Smithsonian Institution, Washington, DC)

Magellan radar backscatter and microwave emissivity measurements provide a global overview of Venus surface processes. The interpretation of these data is often model-dependent, but a broad synthesis is emerging. Weathering processes on Venus occur at rates several orders of magnitude slower than those on Earth, but mechanical and chemical erosion reduce the meter-scale roughness of rocky surfaces over timescales of millions of years. Mass-wasting effects are observed on many of the steep slopes within Maxwell Montes, providing strong evidence for mechanical erosion. A primary source of fine-grained material which can be moved by the wind is impact cratering. These crater deposits have a range of emissivity characteristics, suggesting differences in grain size, deposit depth, or intrinsic chemistry. Volcanic mantling deposits occur in a few locations, and exhibit a wide range of inferred particle sizes. Recent studies of the correlation between highland microwave signatures and geologic setting place constraints on the timescale over which high-dielectric material forms. There is evidence for an upper critical elevation (above which the surface returns to plains-like microwave properties) throughout the equatorial region, but no similarly consistent behaviors are observed for Maxwell Montes. Questions as to the specific mineralogy of the radar-reflective material in the highlands, the distribution of sediments across the planet, and the role of chemical weathering at the surface remain to be addressed by future missions.

STRUCTURES AND EVOLUTION OF CORONAE AND CHASMATA (CHASMATA REGIO, APHRODITE TERRA, VENUS)

C. Cousseau and P. Masson (Laboratoire de Géologie Dynamique de la Terre et des planètes, URA CNRS 1369, Bât. 509, Université Paris-Sud, 91405 Orsay Cedex, France)

Aphrodite Terra is an equatorial highland wich extends over more than 17,000 km (from 45° to 210°E). Wide variations in structure and topography have been identified on Magellan radar imagery along its extension. Eastern Aphrodite (Chasmata Regio, from 140° to 190°E) presents two remarkable chasmata, Dali and Diana, which are ENE-trending troughs of more than 1,000 km long, 100 km wide and 1 to 4 km deep. One side of each trough is flanked by a 3 km high ridge. So elevation differences of 7 km are common in these zones, over horizontal distances of only 30 km. Coronae are also characteristic features of this region. The coronae interfer with chasmata. Nearly all of the structures observed are extensional. The observation of their crosscutting relationships shows three steps in the evolution of these coronae : (1) linear structures (approximatively E-W) due to regional tectonic event ; (2) radial extension and volcanism setting ; (3) significant circular structures. All these structures would be consistent with an upwelling mantle plume origin : firstly, a domical uplift of the surface, due to diapiric rise, causes radial fracturing and volcanism. In the second step, the formation of a rim higher than the corona center would be responsible of circular structures observed. At last, the diapir cooling would have allowed gravitational relaxation to form final topography (creation of a moat, and interior depression).

MORPHOSTRUCTURAL STUDY OF WESTERNMOST ISHTAR TERRA (VENUS)

F. Filippi and J. P. Peulvast (Université Paris IV, Paris / Laboratoire de Géologie Dynamique de la Terre et des Planètes, Université d'Orsay, 91405 Orsay, France)
Ph. Masson (Laboratoire de Géologie Dynamique de la Terre et des Planètes, Université d'Orsay, 91405 Orsay, France)

Westernmost Ishtar Terra consists of three major morphostructural domains : i) Atropos Tessera (rising up from 2 km western side to 5 km eastern side), composed of parallel ridges and wrinkles, ii) Akna Montes, mountain belt (rising up to 7 km) composed of more or less spaced secondary chains (distant from 5 to 20 km), and iii) Lakshmi Planum, high volcanic plains (rising up to 5 km).

By achieving a morphostructural cartography based on Magellan altimetry and imagery, this study aims to investigate the different morphostructural complexes. In addition, a combined study of Akna Montes and Atropos Tessera internal troughs and piedmonts has been initiated. More particularly, the analysis of alterations of the latter structures caused by volcanic filling allows to precise the chronology of volcanic and tectonic processes accounting for the relief's genesis.

DEGASSING HISTORY OF EARTH AND VENUS

S. Franck and Ch. Bounama (Institut für Geowissenschaften, Universität Potsdam, PF 601632, D-14416 Potsdam, F.R.G.)

The thermal and degassing history of Earth and Venus is studied with help of a parameterized mantle convection model including volatile exchange between mantle and surface reservoires. The weakening of mantle silicates by dissolved volatiles may be described by a functional relationship between creep rate and water fugacity. The mantle degassing rate is considered as directly proportional to the seafloor spreading rate and to the melting depth below mid ocean ridges. The rate of regassing depends also on the seafloor spreading rate as well as on the efficiency of volatile recycling through island arc volcanism. Water from the Earth's mantle outgasses rapidly within a timescale of less than 200 Myr for all numerical simulations. In the case of Venus we assume an Earthlike plate tectonic regime up to 500 Myr ago and a Marslike quasi-steady regime after this time. We find less efficient outgassing up to 500 Myr ago in accordance with data about radiogenic noble gasses. The reason for this effect is the Venusian lithosphere that is more hot and dry than in the case of the Earth.

VOLCANISM ON VENUS: CHANGES IN STYLE WITH GEOLOGIC TIME AND IMPLICATIONS FOR EVOLUTIONARY MODELS

J. W. Head [1](Dept. Geol. Scis., Brown Univ., Providence, RI 02912 USA), A. T. Basilevsky (Vernadsky Inst., Russian Acad. Scis., Moscow, Russia), L. Wilson (Planet. Sci. Grp., Inst. Env. & Biol. Scis., Lancaster Univ., UK) and P. C. Hess[1]

We examine the characteristics and stratigraphic relationships of volcanic deposits on Venus and their petrogenetic implications to test evolutionary models. Densely fractured plains of volcanic origin occur between the intensely deformed tessera and later volcanic deposits. The close relationship of this unit to tessera suggests that volcanism was widespread during at least the latter stages of tessera formation. Younger volcanic deposits are very widespread, accreted vertically, are much less deformed, and occur as a wide range of volcanic plains largely overlain by, but interfingering with large discrete sources and edifices. Stratigraphic evidence shows that the initial stages of these widespread plains were emplaced from abundant discrete sources represented by tens of thousands of small shield volcanoes. A distinctive change in style is represented by the next phase, regional plains with wrinkle ridges, which were emplaced in widespread flood-like even, followed by their compressional deformation in the form of wrinkle ridges. This flood phase is interpreted to represent picritic or komatiitic lavas formed by large degrees of partial melting. These widespread plains units were largely followed by the formation of broadly distributed centralized volcanic edifices and sources, and decreasing global fluxes. Latest activity is localized at edifices on volcanic rises, and at rifts where lithospheric thinning has permitted locally enhanced melting and volcanism. One process which can account for this scenario is when a depleted mantle layer underlying a vertically accreting crust becomes unstable and overturns, causing localized crustal thickening (tessera) and extensive volcanism linked to pressure-release melting of upwelling fertile mantle at a range of depths.

LOWLANDS ON VENUS: IMPACT CRATER POPULATION AND RESURFACING HISTORY.

M. A. Kreslavsky (Kharkov Astronomical Observatory, Kharkov, Ukraine)
P. Muinonen (Dept. Geosci. and Astronomy, Oulu Univ., Oulu, Finland)

Impact craters on Venus (Herrick and Phillips, Icarus 111, 387-416, 1994; Strom et al., J. Geophys. Res. 99, 10899-10926, 1994) had been used by a number of authors to constrain resurfacing history of the planet. We investigated variations of crater size-frequency distribution with elevation. For Venus' lowlands (elevation less than 6051 km pl anetary radius), statistically significant relative excess of small craters in compariso n to typical plains (6051...6052 km elevation) was observed. This effect cannot be explained by observational selection. The bias d ue to elevation assessment method was carefully investigated and revealed to be sma ll. Additional atmospheric layer above lowlands cannot influence the crater emplacement so much. The only reasonable explanation for the effect is peculiari ty of crater extinction. Typical plains underwent certain resurfacing that removed small craters more effectively than large. Intensity of this resurfacing on lowl ands was much lower. In respect to large craters the lowlands are younger, than other plains, while in respect to small craters they are older. The following facts are in agreement with the proposed explanation. (1) Lowlands are devoid of volcanic edifices, coronae and other features responsible , at least partly, for resent resurfacing (Price and Suppe, Earth Moon Planets 71, 99 -145, 1995). (2) Relative number of embayed craters on lowlands is smaller than on oth er plains. (3) For the whole crater population percentage of embayed craters is hig her for large craters and lower for small.

CRATER HYPSOMETRY AND EMBAYMENTS IN A SIMULATION OF TOPOGRAPHICALLY GUIDED RESURFACING

P. Muinonen, Dept. of Geosci. and Astronomy, Oulu Univ., Oulu, Finland

Impact cratering and crater removal in volcanic processes on Venus has been simulated by several authors. Comparing crater statistics with the results of the simulations seems to favor a model of global resurfacing with a relatively quick decay of volcanic activity. An alternative model of an equilibrium between crater emplacement and randomly distributed resurfacing units has also been proposed but always found unsatisfactory by virtue of either an non-uniformity inflicted to the crater distribution or the high proportion of embayed craters produced. While a global resurfacing is easily modelled by plainly erasing every crater on the surface, a volcanic renewal in patches of a limited extent is a more complex task. Still it has often been reduced to a 2D problem of superimposing craters and simplified resurfacing flows. In the present work the equilibrium resurfacing is tested by a 3D simulation which begins from a surface with no topography. It creates randomly located resurfacing patches of a low-viscosity material. Their shape is determined only by an artificial viscosity parameter and by the topography of earlier patches, since the occasionally added craters are assumed reliefless. The maximum proportion of embayed craters as a function of the diameter is calculated and found to be lower than for any 2D model. The hypsometry and the distribution of craters in respect to it are produced by the simulation and compared with their counterparts on Venus.

STRATIGRAPHIC POSITION OF SOME CORONAE ON VENUS

A. A. Pronin (Univesity of Oulu, Dept. of Geosciences and Astronomy, Finland. Permanent address:Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences, Kosygina st. 19, Moscow, 117975 Russia)

Abstract. An attempt is made to evaluate the age status of a class of Venusian structures identified in Venera-15/16 radar coverage of Venus and named coronae. The effort is based on detailed mapping of small areas of the surface that include coronae, imaged by the Magellan spacecraft, with radar images of the C1--MIDR and F--MIDR format represented in the form of mosaics. Geological and structural mapping based on a photogeologic analysis of images of the surface in the vicinity of some 30 coronae was used to construct local stratigraphic columns for areas including both coronae and regional geological units that are part of the accepted stratigraphic guidelines (Basilevsky and Head, 1995, a). The result made it possible to demonstrate that the population of coronae was formed practically throughout the geologic history of the Venusian plains. The stratigraphic position of the coronae throughout the history of the plains, with due consideration for model estimates of the lifetime of their population, indicates that planetary activity associated with coronae continued after the period of the most intensive tessera-forming deformations for at least another 20 to 30% of the observed history on an area of about 10% of the Venusian surface.

RELATIVELY THIN SURFACE LAYER ON VENUS

J. Raitala & K. Kauhanen (Geosci. and Astronomy, Univ. of Oulu, FIN-90570 Oulu, Finland)

Perpendicular fracture sets within highlands display two-dimensional boudinage fracturing of a brittle surface layer over a less-viscous substratum. Fracture sets are controlled by surface lineation and tension. The 470°C surface temperature, 650°C dry olivine isotherm and 15 to 20°C/km temperature gradient suggest a low-viscous layer at depth of 12 to 9 km, respectively. This is supported by certain fault geometries. Salme Dorsa and Tusholi scarp are places where the uppermost lithospheric layer has been bent beside of the ridge belts by either the load or lateral stress resulting in trough and bulge formation. At Salme Dorsa there are even grabens close to the bulge crest. The same boundary conditions and the 12 to 9 km thick uppermost lithosphere estimation is valid here, too. On the other hand, this bending allows some estimates to be drawn of the thickness of the uppermost elastic lithosphere layer. The minimum value of the thickness of the bended lithospheric layer ($h \approx 3$ km) is obtained from a flexural approach. This value is the absolute mimimum and rather small if compared to other studies. By assuming a bending moment the thickness of the layer is increased due to the effect on plate curvature. The most probable values of the uppermost crustal layer thickness are thus within the range of 5 to 12 km.

POST GLOBAL RESURFACING VOLCANIC ACTIVITY ON VENUS

R.G. Strom and D.D. Dawson (Dept. of Planetary Sciences, Univ. of Arizona, Tucson, AZ, 85721, U.S.A.)

New Monte Carlo simulations of the amount of volcanic activity following the latest global resurfacing event have been conducted using a revised impact crater database. These simulations also determine the time to end the global resurfacing event based on an average surface age of 500 my. The amount of post-global resurfacing volcanic activity and the time required to terminate the global resurfacing event are dependent on the number of lava embayed impact craters and the number of these craters embayed by the terminal end of the global resurfacing event. The total number of lava embayed craters is about 50 out of a total crater population of about 940. It has been estimated, based on stratigraphic considerations, that about 15 craters have been embayed by the terminal end of the global resurfacing event. The simulations take into account craters, ejecta deposits and outflows, haloes and parabolic features surrounding some craters, and shock induced splotches. The simulations indicate that between 4 and 8 percent of the surface has been resurfaced by volcanic activity since the end of the global resurfacing event, and that the time to terminate the global resurfacing event was between 75 and 120 million years. This is much less than intraplate volcanism on Earth.

INVESTIGATION OF DENDRITIC CHANNEL SYSTEMS ON VENUS

P. Weddeling (Institut für Geophysik, Kiel, D-24148 Germany)
P. Janle (Institut für Geophysik, Kiel, D-24148 Germany)

Channels formed by low-viscosity fluids are abundant on the surface of Venus. Based on FMAP Magellan images, we investigated the morphology of dendritic flow systems and their relation to the present-day topography. A dendritic flow syste m located at 87°*E*, 8°N, north of Ovda Regio, shows at least 3 stag es of tributari e all confined to the southern (up-hill) region of the stream.

PROGRESS IN UNRAVELLING THE GEOLOGIC HISTORY OF VENUS

R. S. SAUNDERS (Jet Propulsion Laboratory, Pasadena, CA, 91109, USA)

The Magellan mission collected Venus data from the start of radar mapping in mid September, 1990 until October, 1994, when the spacecraft was maneuvered into a lower orbit and caused to plunge into the atmosphere to provide data on Venus's upper atmosphere. The four year mission provided 120m resolution images of more than 98% of the planet, with many areas mapped up to three times. Altimeter mapping provided global topography, roughness, and radio properties. Radio tracking of the spacecraft in the close circular orbit achieved by aerobraking the spacecraft, provided a global gravity field that is revealing the interior density distribution. The gravity observations allow studies of features as small as a few hundred km across. Systematic geologic mapping has begun using all the Magellan data. Geologic mapping at 1:5,000,000 scale is integrating observations of surface characteristics and geophysical inferences drawn from topography and gravity. Venus is not as geologically active as Earth and has had a different evolutionary history. The generalized history depicts Venus as tectonically violent during an early and unknown epoch. A relatively brief period dominated by volcanism may have occurred some 300 to 1000 m years ago. This was followed by a relatively quiet period up to the present with scattered volcanism, wind activity, and impact. This paper presents the range of geologic hypotheses for Venus that have emerged since the Magellan mission.

HOW DOES VENUS LOSE HEAT

D.L. Turcotte, (Dept. Geol. Sci., Snee Hall, Cornell Univ., Ithaca, NY 14853 USA)

The way in which a terrestrial planet loses heat is primarily responsible for the tectonic and volcanic evolution of the planet. In the case of the earth the plates of plate tectonics are the thermal boundary layers of mantle convection cells. This is not the case for Venus. Cratering studies show that near a global volcanic resurfacing event occurred on Venus during a relatively short period (10-50 Myrs) at about 500 ± 150 Myrs before present. This global resurfacing event suggests that episodic subduction events may have occurred on Venus rather that the uniformitarian subduction occurring on the earth. A global subduction event would have resulted in a period of extensive surface volcanism, local tectonic and subduction events, and a very high loss of heat from the planetary interior. Eventually a thin global lithosphere would stabilize but would be subject to considerable tectonic deformation. The result is the tessera terrains. As the surface stabilized the relatively smooth volcanic plains formed. As the lithosphere thickened volcanic constructs evolved. Any comprehensive theory for the evolution of Venus must also explain the various highland regions. Several regions such as Beta can be associated with present or recent tectonic and volcanic processes, probably due to mantle plumes rising from a basal thermal boundary layer. Others such as Ishtar Terra may represent light silicic "continental" material that may have survived the global subduction event but was sufficiently tectonized that there is no visual evidence for an earlier origin. A variety of observations favor a relatively thick elastic lithosphere at the present time (flexural studies, lack of crater relaxation) such a thick elastic lithosphere is consistent with a conductively thickening lithosphere (with relatively small basal heating) since the last subduction and resurfacing event. Artimus chasma (corona) can be associated with an aborted global subduction event.

PS2 Evolution and state of surfaces, crusts and lithospheres of planetary bodies

02 Mars: new efforts of understanding its evolution

Convener: Chicarro, A.
Co-Convener: Squyres, S.W.

Seismic programme "Penetpator Mars-96": unfinished pages are turned over

E.M. Galimov, Yu.A.Surkov, GEOCHI RAS
O.B. Khavroshkin, V.V. Tsyplakov, UIPE RAS

An analise of penetrators as a new kind of cosmic research apparatus-instruments is given. Instrumental/metodological and scientific bases of seismic experiment "Mars-96" and also expected scientific results are covered in detail; modification of specialised seismic mini-penetrator is proposed and its limited capabilities are determined based on the concepts of physical seismology. Some problems of future investigations and a probable role of penetrators and penetration are touched upon. The causes of Mars's programmes failures are analyzed putting emphasis on event 16.XI.96. Courses of a decision of the problem are examined.

Slope Measurements in the Valles Marineris and Kasei Vallis, Mars: A Comparison Between Photogrammetry and Photoclinometry

Hauber, E. and Mosangini, C. (DLR - Institute of Planetary Exploration, Rudower Chaussee 5, 12489 Berlin, Germany)

Two of the most prominent structures of the martian surface are the large equatorial canyons of the Valles Marineris and the circum-Chryse system of anastomosing outflow channels. The knowledge of topography is of utmost importance in the understanding of the geological processes responsible for the formation of both the canyons and the valleys. Tectonic information like the dipping of fault planes, as well as information about the amount of erosion and sedimentation, can often be gained only through three-dimensional analysis of imaging data. In planetary science, two common techniques have been used to derive topography: 1) the photogrammetric approach is based on the identification of common points in two or more images, a subsequent bundle-block adjustment, and the derivation of object point coordinates which can then form the basis for a digital elevation model. 2) in photoclinometry, the brightness variation of the surface (i.e. the DN values in an image) is due to varying illumination caused by topography (shape from shading), assuming that the albedo is homogeneous along the measured profile. Small-scale features (e.g. small grabens near the main canyons, valley walls) were selected for the measurements where appropriate high-resolution Viking Orbiter imaging was available. The results of the two techniques are compared and the implications for the geologic interpretation are discussed.

VOLCANIC INTRUSIONS ON MARS: HEAT SOURCES TO MAINTAIN VIABLE ECOSYSTEMS?

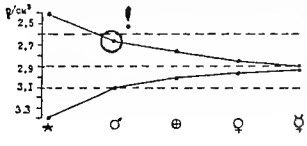
James W. Head III (Dept. of Geological Scis., Brown Univ., Providence RI, USA) and Lionel Wilson (Planetary Science Group, Inst. of Environmental and Biological Scis., Lancaster Univ., Lancaster UK)

We explore conditions under which volcanic intrusions can provide heat sources of sufficiently long duration to maintain environments conducive to viable ecosystems, and we examine the types of surface features that these intrusions would produce as a guide to future landing site selection. The main difference between terrestrial and martian volcanic reservoirs is related to the lower gravitational acceleration on Mars; the interplay between stresses arising due to gravity and stresses linked to the elastic properties of rocks causes all martian magma reservoirs to be centered at greater depths and to be larger in both horizontal and vertical dimensions. The greater magma volumes housed by these reservoirs cause laterally propagating rift-zone dikes to be both horizontally and vertically more extensive and wider than those on Earth. If a 5-m-wide dike is intruded into a new region the heat pulse will raise the temperature above the melting/boiling point for several years; this affects a region about 30 m wide. If dike emplacement is concentrated in a volcanic rift zone, significant local "warm zones" can exist down to depths of several kilometers; earlier higher geothermal fluxes would have extended the depth of the zone within which water could be present as a liquid. Our analysis suggests that local volcanic heat sources inevitably present in the rift zones on the flanks of large martian volcanoes could have very significantly extended the sizes of regions within which water could persist as a liquid for time periods of at least tens and probably hundreds of millions of years, and that these are excellent candidate landing sites for future exploration.

HOW REGULAR IS PLANETARY TECTONICS:MARTIAN TEST

G.G.Kochemasov,IGEM,Russian Academy of Sciences

Wave planetary tectonics/Kochemasov,1986-96/implys regular change of planets'properties with solar distance.From Mercury to asteroids sphericity of cosmic bodies decreases(wave warping becomes coarser),surface relief range,tectonic "granularity",surface compositional dichotomy (Fig.)increase.Lengths of standing waves warping bodies in 4 directions are proportional to their orbital periods.In this regularity a crucial point is composition of martian highlands. We predict their average acid composition(kind of acid plagioclasite-albitite,syenites &so on) &hence low density.A majority of scientists using spectral data believe that highlands are basaltic &hence dense.Missions to Mars will resolve this contradiction & choose between 2 paradigms professing regularity or randomness in planetology.Showm are av. densities of planetary low-,highlands & common asteroids/Kochemasov,94-96/.



A COMPLEX MODEL OF MARTIAN UPPER LAYER

E.M. Koshlyakov (Institute of Physics of the Earth, B.Gruzinskaya 10, Moscow 123810, RUSSIA)

A complex model of crust and lithosphere of Mars is presented. By data of topography and faults distribution it is possible to estimate a deformation of the surface of Mars and its lithosphere thickness. Rheological properties of rocks permit to determine a thermal boundary of the elastic lithosphere and to restrict a value of near-surface temperature gradient. The crust thickness may be restricted from below by topography and gravity data, and from above by the boundaries of basalt melting and of gabbro-eclogite type transition. Depths of these boundaries in one's turn depend on temperature distribution and mineralogical structure of the crust. Thus mechanical, thermal, mineralogical and rheological factors are connected with each other and constraining a united model, which include all of these factors, may be important for understanding the structure and the evolution of Mars.

THE MOUTH OF ARES VALLIS, MARS: GEOLOGY, STRATIGRAPHY AND CRATER COUNTING

A.G. Marchenko, A.T. Basilevsky (Vernadsky Institute, Russian Academy of Sciences, Kosygin St., 19, Moscow, Russia 117975)
G Neukum, E. Hauber, H. Hoffmann, and A.C. Cook (DLR Institute fur Planetenerkundung, 12484, Berlin, Germany)

Photogeologic study of the mouth of Ares Vallis, an outflow channel on Mars, has been made. The future Mars Pathfinder landing site is planned to be within this area. To understand the geology and the geologic history of the area under study (15°-30°N, 26°-36°W) 320 low- and medium-resolution Viking Orbiter images of this area were studied. Impact craters were counted on 47 medium- and 7 low-resolution images. As a result of the work, the 1:2 M geologic map has been made. Mapping revealed 14 main units with distinct morphology. Crater density counting was used to study age relations in cases where the crater statistics were reliable. Materials of two main stages (older and younger) of fluvial activity have been distinguished. Crater countings and photogeologic study suggest that probably the last flood during the younger stage was from Tiu Vallis. Results may help to interpret the future Mars Pathfinder data.

VOLCANO-TECTONIC EVOLUTION OF TERRESTRIAL AND MARTIAN HOTSPOTS

D. Mège and P. Masson (URA CNRS Géophysique et géodynamique interne, Université Paris-Sud, Bt. 509, 91405 Orsay, France, e-mail: daniel.mege@geol.u-psud.fr)

The early volcano-tectonic events associated to the Tharsis (T) hotspot on Mars, centered on the Syria Planum area, are compared to the early events at the 1.67 Ga old Mackenzie (M) and the 17-00 Ma Yellowstone (Y) hotspots. A common plume tectonics model can account for many of the hotspot volcano-tectonic characteristics, including: [1] early thermal uplift (T, M, Y) associated to peripheral compression (T, not evidenced at M, Y, but similar to compression around a possible 2.7-2.6 Ga old Yilgarn hotspot on Earth); [2] thermal subsidence (T, M, Y) initiating wrinkle ridge formation (T, M?, Y), then flood basalt eruption (T, M, Y), followed by isostatic adjustment enhancing thermal subsidence and wrinkle ridge formation (T, M?, Y); [3] mafic dyke swarm emplacement contemporaneous to flood basalt emplacement (T, M, Y); [4] two-arm (T, Y) or three-arm (M) rifting in extensional setting, following dyke swarm geometry, either aborting (T, Y) or successfully developing into ocean (M), depending on lateral boundary conditions; [5] lithosphere/hotspot relative motion leading to formation of a central silicic volcanic chain after quiescence of the diffuse mafic activity, and emplacement of a thick batholith below the volcanic chain (T, M?, Y). Although one of these hotspots is active, one is fossil, and one is extraterrestrial, they appear to share many tectonic and magmatic features. The differences may depict influence of factors such as geodynamic setting (e.g., influence of Basin and Range extension and Pacific subduction in the Yellowstone case), and difference in gravity on both planets.

IMPACT DISRUPTION OF OXIDIZED NEAR SURFACE STRATIGRAPHY ON MARS

A. P. Zent (SETI Institute/NASA Ames)

We test the hypothesis that organics will not be recoverable from beneath an oxidized layer of the martian regolith, because impact gardening will mix all organics into the oxidizing zone over time. The atmospheric cutoff of impactors limits craters to greater than about 50 m. Hence, the regolith stratigraphy on all scales ≤ 12 m is stable on timescales of 10^8 to 10^9 years, based on calculations using Melosh's (1989) equations. As long as the lifetime of the atmospheric oxidant is less than 10^8 years, highly probable, the equilibrium profile will re-establish itself between impacts. Organics added in impacts should be recoverable beneath the diffusion depth. Preliminary analysis of new H_2O adsorption data at conditions appropriate to Mars, if extrapolated to explain H_2O_2 diffusion as well, suggest the extinction depth of peroxide lies within approximately the upper meter of the regolith. Materials at depths greater than about 100 m should have had very limited opportunity to become oxidized.

SURFACE EXTENSION AND DYKE EMPLACEMENT AT ALBA AND TANTALUS FOSSAE, MARS

D. Mège (URA CNRS Géophysique et géodynamique interne, Université Paris-Sud, Bt. 509, 91405 Orsay, France, e-mail: daniel.mege@geol.u-psud.fr)

Alba and Tantalus Fossae form a series of roughly NNE/SSW-oriented fan-shaped troughs hundreds of kilometers long, converging southwards toward the Alba Patera volcano, and fanning northwards in the Vastitas Borealis plain. Close to Alba Patera, the troughs display evidence of normal faulting and development of segmented grabens. In Vastitas Borealis, evidence of normal faulting is sparse, troughs are narrower, and evidence of spatter cone formation parallel to some of these troughs is found, suggesting that lateral crustal growth through dyke emplacement occurred parallel to tectonic extension.
Relationships between dyke emplacement and tectonic extension has been modeled through boundary element calculations using a rock-mass failure criterion. The results show that realistic magma pressure in single dykes (<1 m) is unlikely to have been a major factor in graben development, although it may have influenced initiation and location of surface extension. Terrestrial examples suggest that thick dykes generally form from multiple pulses, each pulse intruding the centre of the formerly injected magma sheets forming the dyke. Emplacement of each sheet causes tensile stress above its tip, partly released through fracturing, allowing each new magma sheet to reach a shallower crustal level. Following this mechanism, the maximum tensile stress at the upper dyke tip is always more or less equal to the tensile stress generated by the last magma pulse, and therefore, never large enough to cause graben formation. Thus, emplacement of thick dykes does probably not alter the results obtained for thin dykes.

The Global Shape of Mars: A Recomputation of the Viking Control Point Network

W. Zeitler, J. Oberst (DLR - Institute of Planetary Exploration, Rudower Chaussee 5, 12489 Berlin, Germany)
T. Ohlhof (Technische Universität München, Munich, Germany)

Image control-point network analysis is used to determine the global shape of Mars. For the analysis, we adopted a large set of 18,975 images coordinates that were measured in 1157 Viking Orbiter images for an earlier control point network analysis [1]. After inspection, 15,978 of these points were selected for our new analysis; these were measured in 1126 individual images and belonged to 3355 individual surface points. The original nominal pointing data of the cameras were used in the computation process. However, new trajectory data, the result of orbit restoration using Viking Project tracking data and the latest Mars gravity model GMM-1, were used in the bundle block adjustment. Previous trajectory data were known to include large errors of up to a few tens of kilometers. In the adjustment, we corrected the camera pointing and determined the coordinates of all 3355 surface points. The resulting x-, y- and z- coordinates have errors of 1331, 1526 and 1455 m, respectively. The accuracy of the pointing data are estimated to be 0.004 gon. The standard deviation of the image coordinates is 8.88 microns (=0.75 pixels). Using this large set of surface point coordinates, global shape models of Mars and large-scale topography will be discussed.

PS2 Evolution and state of surfaces, crusts and lithospheres of planetary bodies

03 Other planets: new results

Convener: Janle, P.
Co-Convener: Basilevsky, A.T.

MAJOR-ELEMENT CHEMISTRY OF VENUS ROCKS: COMPARISON WITH EARTH'S MORBs AND OCEANIC ISLAND-ARC BASALTS (PRELIMINARY RESULTS)

Abdrakhimov A.M. (Lomonosov State University, Vorobyevy Gory, Moscow, 117124 Russia)

Three basaltic rocks measured on Venus are compared in major-element composition to Earth's fresh N- and E-MORB tholeitic basalts and oceanic island-arc calc-alkaline basalts. Results of the comparisons show: The Venera 14 basalt resembles the transitional N- to E-MORB in its MgO-K_2O contents. In the Vega 2 basalt, high MgO and low SiO_2, K_2O, TiO_2 contents may evidence on rather primitive material with N-MORB-like Al_2O_3 content. The Vega 2 basalt may be close to high-Mg, high-Fe, low-Ca volcanic rocks, more primitive than the rocks under consideration. High K_2O content in the Venera 13 material makes it out of both tholeitic and calc-alkaline basalts, though its Al_2O_3 and TiO_2 contents are similar to those in N-MORB's. Thus, none of these Venus basalts is similar in all of the major-elements neither to the basalts derived from the depleted (N-MORB) and enriched (E-MORB) mantle reservoirs, nor to the subduction-related calc-alkaline basalts.

PHANEROZOIC HISTORIES OF EARTH AND VENUS

A.T. Basilevsky (Vernadsky Institute, 117975, Moscow, Russia)
J.W. Head (Geological Dept., Brown University, Providence, R.I. 02912 USA)

The well-known paleogeographic considerations show that the Phanerozoic history of Earth was controlled by plate tectonics with accretion of continents into supercontinents and their subsequent break-up. The global volcanic rate was dominated by mid-oceanic rise (MOR) volcanism realized through numerous discrete eruptions of relatively small portions of basaltic lava almost simultaneously in many places of the global MOR system. The morphologically recognizable part of the geologic history of Venus covers the last 300 to 500 m.y. No reliable traces of plate tectonics are seen in the morphological record. The beginning of this time period was marked by intensive tessera-forming tectonism soon changed into vast basaltic floods. Though the eruption style of the latter (globally distributed volumnious effusions) was different than the MOR vocanism their globally averaged rates seem to be close. This phase lasted for 10's to ~ 100 m.y. and then changed into a phase of significantly lower volcanic and tectonic activity concentrated mostly in rifts. The reason for the observed difference in the geologic histories of these two planets is not clear.

SOLIDIFICATION OF IMPACT MELT BODIES - A CASE STUDY ON THE SUDBURY MUILTRING-IMPACT STRUCTURE

A. Deutsch (Inst. f. Planetologie, D-48149 Münster, Germany), B.A. Ivanov (Inst. f. Dynamic of Geospheres, RAS, Moscow, Russia), A.A. Ariskin (Vernadsky Inst., RAS, Moscow) and M. Ostermann (D-48149 Münster)

Understanding the thermal evolution of voluminous impact melt bodies is crucial for the interpretation of large basin-scale impact events on terrestrial planets, especially, the moon. The possibility that a thick impact melt sheet can differentiate like a „normal" magmatic body has severe consequences for the identification of impact-site related rocks, being either impact-derived „crustal" lithologies, or of mantle origin. It was realized recently that the solidification of melt bodies depends upon the concentration of cold clasts in the melt, with the number of clasts drastically decreasing for basin-sized impacts. To analyze this problem, the 1.850 Ga, about 250 km sized Sudbury multi-ring basin (Canada) is used as example. This structure contains an about 2.5 km thick impact melt body with a volume on the order of $2x10^4$ km^3 - the Sudbury Igneous Complex, which is differentiated. Thermal modeling, using known geological data as boundary conditions, yields the following results: Cooling of the impact melt sheet from the initial temperature of 2000K, below liquidus at 1450K, lasted about 100 ka, and below solidus at 1270K, about 300 ka. This time scale sets within a factor of two, the limits for geochemical-petrological modeling to constrain the rate of differentiation. We will discuss the problem of proper scaling for comparison of terrestrial and lunar impacts.

COMPARISON OF FRACTAL LINEAMENT ANALYSIS ON EARTH AND VENUS - FIRST RESULTS

M. Hammer and P. Janle (Institut für Geophysik der Universität, D-24098, Germany)

The application of fractal analysis to geophysical problems often lacks in the interpretation in respect to physical processes. We have determined the fractal dimensions after several steps of image processing for radial and circular (ringrifts) structures on Earth and Venus.The structures exhibit circular (ringrift) and radial lineaments. In general, structures dominated by circular lineaments have a nearly uniform fractal dimension different from the nearly uniform dimension of radial structures. In order to demonstrate relationships of the formation mechanism of structures with the same fractal dimension examples from botany have been investigated. This resulted in a high degree of fractal dimensions for plants of a high degree of relationship. Transferring the result to tectonic structures means that a high degree of agreement in fractal dimensions indicates similar processes for their formation. In order to test this result the fractal dimensions for the Alps and Andes on Earth and Maxwell Montes on Venus have been determined. Alps and Andes, formed by collisions of plates of terrestrial lithosphere, show similar fractal dimensions different from that of Maxwell Montes. This is in agreement with the absence of plate tectonics on Venus and consquently a different formation mechanism for Maxwell Montes

BASALTIC VOLCANISM IN THE SOLAR SYSTEM: PERSPECTIVES ON EARTH HISTORY

James W. Head III (Dept. of Geol. Scis., Brown Univ., Providence RI, USA) and Lionel Wilson (Planet. Sci. Grp., Inst. Env. & Biol. Scis., Lancaster Univ., UK)

A wide range of extensive basaltic volcanic provinces and styles are common on the terrestrial planets and satellites and their presence, characteristics, and geologic and temporal settings offer a potentially important perspective for basaltic volcanism in Earth history. On the Moon, shallow magma reservoirs and large shield volcanoes are not known. The relatively low-density, thick anorthositic crust creates a density trap for rising basaltic magmas; dikes sufficiently large to reach the surface are uncommon but often result in large-volume, high-effusion-rate eruptions; single eruptive phases are predicted and observed to be in the range of several hundred cubic km. On Mars, massive shield volcanoes have formed on the stable lithosphere over long-lasting hot spots; shield heights are up to 25 km above the adjacent plains. The lower gravity on Mars causes dikes and vents to be wider and eruptions to be characterized by higher effusion rates; cooling-limited lava flows on Mars would be about six times longer than on Earth. On Venus, high atmospheric pressure influences the presence and distribution of neutral buoyancy zones, in a manner similar to that on the Earth's seafloor. Extremely large volcanic outflows are observed and some lava channels are in excess of several thousand km in length. In addition, the cratering record has been interpreted to mean that Venus underwent rapid and massive planet-wide volcanic resurfacing about 300 Ma ago, an event possibly related to the overturn of a depleted mantle layer resulting from the vertical accretion of a basaltic crust. This underlines the possibility of episodic and catastrophic large-scale volcanic emplacement in planetary history, including the early Earth. The planetary record should be of use on Earth in recognizing deposits formed under earlier different conditions and in distinguishing plate tectonic influences from those linked to deeper interior processes.

CORRELATING He, Ne, and Ar IN THE ATMOSPHERE OF MERCURY WITH THE COMPOSITION AND STRUCTURE OF THE CRUST.

R. M. Killen, and T. H. Morgan (Southwest Research Institute, PO Drawer 28510, San Antonio, Texas 87228)

The abundances of the noble gases in the atmosphere of Mercury should provide an important constraint on both the composition and the structure of the crust. The bulk of the ^{40}Ar found in the atmosphere of Mercury must be radiogenically derived, as is likely true for a large fraction of the He. The relative abundances should be critically sensitive to the K/U ratio of the crust and the fraction of the interior which has outgassed. The atmosphere is juvenile, and the loss of radioactive decay product gases from the upper crust can be modeled using modern multi-path diffusion techniques developed for terrestrial applications. Only He was measured during the Mariner 10 flybys. Determination of the burden of ^{40}Ar together with crustal measurements of the major-element surface composition using an X-ray, gamma-ray spectrometer would provide unique discriminators for the determination of the origin and history of the planet. Measuring the Ne abundance would allow us to compute the overall fraction of the solar wind which is reaching the surface, and to derive the likely supply rate of solar wind-derived ^{36}Ar and He. Changes in the Ar and He abundances, not correlated with Ne variations would indicate active crustal processes. It is possible to measure the He, Ar, and Ne abundances form Earth orbit with appropriately designed EUV/FUV telescopes. From an orbital platform several measurement approaches are possible, including measurements with UV spectrometers, neutral mass spectrometers, and ion mass spectrometers.

K-U-Th CONSTRAINTS ON VENUS PETROGENESIS

Olga V. Nikolaeva (Vernadsky Institute, Russian Academy of Sciences, Kosygin St , 19, Moscow, Russia 117975)

Relative to Earth's N-MORB all of the K, U, Th-measured rocks of Venus are enriched in all of these incompatible elements. All of moderately enriched (Venera 9, 10 and Vega 1, 2) rocks, basaltic in composition, are similar to each other in their U>K trend, but differ from highly enriched (Venera 8) material with K>U trend. These differences imply that the enrichment pattern for the basaltic rocks could be controlled neither crystallization of N-MORB-type magma, nor contamination of that magma by the Venera 8 material within the crust, and the Venera 8 material could not be evolved from the magma of any of the basalts. Based on calculations, the K-U-Th pattern for any of the measured Venus rocks could not be controlled by batch partial melting of primitive mantle. The Venera 8 material may be produced as 1-2% partial melt from eclogitic tholeite. But all of the basaltic rocks are apparently not, as their U>K trend is opposite to the model. In overall, the K-U-Th variations in the measured Venus basalts occur at nearly constant K/U ratio, while these in the K-U-Th systematized Earth's N-MORBs and oceanic island-arc volcanics - at nearly constant Th/U ratio. This may suggest an unusual composition of the basalt source(s) and/or unusual fractionation process(es) on Venus.

PS3 Atmospheres of the terrestrial and outer planets

Convener: Lewis, S.R.
Co-Convener: Hourdin, F.

COMPARATIVE PLANETOLOGY AND LIFE

G.G.Kochemasov,IGEM,Russian Academy of Sciences

Comparative planetology becomes real being put on 1 background which is wave warping(shaping)of cosmic bodies by different wavelengths depending on solar distance/Kochemasov,1991-96/.Sphericity(=stability) of bodies diminishes with increasing solar distance from 0,973(Mercury,half-wavelength πR/16)to 0(asteroids,no planet,πR/1)being 0,830(Venus,πR/6),0,637 (Earth,πR/4),0,420(Mars,πR/2).R-body radius.The indexes are calculated as ratio of the area of inscribed in circle polygon(its shape is tied to number of standing waves;Fig.)to the circle area.Earth is unique by its near to the "golden section"value.Let's use these indexes to compare "steady life"conditions at Venus,Earth,Mars,where life is or was possible. Life structure supposes creation &destruction(birth & death).Too much one or another both tend to suppress life,only right proportion ensures steady life. Such "golden section" proportion is only at Earth. At Mars destruction prevails over creation(0,420),at Venus creation prevails over destruction(0,830). At Mars weak signs of past life are possibly found! At Venus its exuberant growth 0,5-0,7 mlrd.y.ago producing enormous quantity of CO_2 (degassing through primitive biocycle?)with known consequences also ended badly/Kochemasov,1996/

ABOUT NUMERICAL MODELLING OF GLOBAL MOTION IN PLANETARY ATMOSPHERE

Nataly.M.Astafyeva, S.S.Moiseev (Spase Research Institute, Profsoyuznaya, 84/32, 117810 Moscow, Russia)

The flow between two spheres rotating with different angular velocities consist of a differential rotation about the axis and a meridional circulation and depends on three similarity parameters: the Reynolds number, the relative gap size and the relation between angular velocities of boundary spheres. The theoretical and experimental investigations of a shear viscous flow in a spherical layer at different values of similarity parameters have shown that there are observed all tipes of hydrodynamical instabilities and as a result - a great variety of the secondary flow regimes. All these problems (with histeresis and nonuniqueness of regimes) are very actual and important for analysis and modelling of global motions in planetary atmospheres: heat fluxes and stratification give rise to additional types of instabilities (convective, baroclinic). We have investigated the influence of density stratification on a shear spherical flow and have estimated a set of parameters which will be necessary for numerical modelling of the global atmosphere dynamics of planet-giants.

THE MULTILAYERED CLOUD STRUCTURE OF JUPITER AND SATURN

S.K. Atreya (The University of Michigan, Dept. Atmospheric, Oceanic & Space Sciences, Ann Arbor MI, 48109-2143, USA)

Below their visible clouds of ammonia, the atmospheres of both Jupiter and Saturn are expected to have cumulus-type cloud layers of ammonium hydrosulfide (or polysulfide), water ice and possibly an aqueous solution (of water and ammonia) These clouds could extend down to the 20-bar level in Saturn's atmosphere, should the oxygen elemental ratio be enhanced relative to solar by the same factor as the carbon elemental ratio. In Jupiter's atmosphere the water/ice-solution cloud could be present as deep as the 10-bar level. The Galileo Probe gave the first measurement of the cloud structure in Jupiter's deep atmosphere. Along the Probe's trajectory only two very thin wispy clouds were detected; there is a possibility of a third even less tenuous cloud. We demonstrate that the characteristics of these clouds are consistent with the thermo-chemical equilibrium model which takes into account the depleted abundances of condensible volatiles measured by the Galileo Probe and Orbiter instruments for the 5 micron hot spot region of the Probe entry. As for Saturn, the meteorology of its deep atmosphere can be best studied with an entry probe.

OBSERVATIONS OF THE GIANT PLANETS WITH THE SHORT-WAVELENGTH SPECTROMETER OF THE ISO SATELLITE

Th. Encrenaz, E. Lellouch, B. Bézard, P. Drossart and M. Roos-Serote (DESPA, Observatoire de Paris, F-92195 Meudon, France)
H.Feuchtgruber and M. F. Kessler (ISO Science Operating Center, Villafranca, E-28080 Madrid, Spain)
Th. de Graauw (SRON, Groningen, NL-9700 AV, The Netherlands)
M. J. Griffin (QMW College, London E1 4NS, UK)

Observations of the four Giant Planets have been performed in 1996 with the Short-Wavelength Spectrometer of the ISO satellite. The main results are the followings: (1) the first detection of the R(2) HD line at 37.7 μm in Jupiter, leading to an estimate of 1.8 (-0.5, +1.1) 10^{-5} for the Jovian D/H ratio; (2) the first detection of water vapor in the stratospheres of Saturn, Uranus and Neptune, through several emission lines in the 25 - 45 μm range; (3) the first detection of CO_2 in the stratospheres of Saturn and Neptune, through its ν_2 band at 15 μm; (4) the first detection of vapor vapor in the deep troposphere of Saturn, at 5 μm; (5) the evidence for a high temperature in the upper stratosphere of Jupiter, through the first detection of the CH_4 - ν_3 band at 3.3 μm; (6) the evidence of a spectral signature, at 3 μm, of the jovian cloud at about 0.5 bar, presumably due to a mixture of NH_3 ice. The presence of water vapor and carbon dioxide in the stratospheres of the giant planets is probably due to influx from the rings, planetary satellites and/or meteorites.

ANALYSIS OF JOVIAN CLOUD STRUCTURE AND ATMOSPHERIC COMPOSITION FROM GALILEO/NIMS

P.G.J. Irwin, A.L. Weir, S. Smith, P.J. Smith, F.W. Taylor, University of Oxford

The Near Infrared Mapping Spectrometer (NIMS) aboard the Galileo spacecraft has made the first complete measurements of the near infrared spectra of Jupiter from 0.7 to 5.2 microns which are unobscured by terrestrial constituents. This spectral range covers both the reflected sunlight and thermal emission ranges and thus provides a unique opportunity to decouple the contributions of clouds and gas constituents.

Using a correlated-k, multiple scattering radiative transfer model, these spectra have been analysed and reveal great variability in both cloud properties and gas composition. In general it is seen that in regions where the cloud optical depths reduce to allow more thermal emission in the 5 micron window, the mixing ratios of H_2O, NH_3, and PH_3 all reduce, both at the deep levels sounded at 5 microns and above the cloud tops, revealed by absorption features in the near IR. Such behaviour is consistent with the theory that these are areas of dry, downwelling air. In addition, Mie scattering models of ammonia ice and NH_4SH clouds suggest that the ammonia cloud is made up of small particles (approx. 1 micron) while the NH_4SH particles are much larger (50 microns). Indeed, it is found that a significant opacity of large ammonia ice particles would give an erroneous slope to the 5 micron emission window and may be discounted.

THE EUROPEAN MARTIAN CLIMATE DATABASE

M. Collins, S.R. Lewis and P.L. Read (University of Oxford, Department of Physics, Clarendon Laboratory, Parks Road, Oxford OX1 3PU, U.K.)
F. Forget, R. Fournier, C. Hourdin, F. Hourdin and O. Talagrand (Laboratoire de Météorologie Dynamique du CNRS, Ecole Normale Supérieure, 24 rue Lhomond, 75 231, Paris Cedex 05, France)
J.-P. Huot (ESTEC, Noordwijk, The Netherlands)

This paper describes a new Martian Climate Database (MCD), developed in response to a European Space Agency invitation to tender, which is based directly on output from two Global Circulation Models (GCMs) of the Martian atmosphere and surface environment. The models have been developed by groups in Oxford and Paris and have been validated using available data from past missions. Consequently, they represent the best current estimate of the Martian environment. A previous approach used by spacecraft engineers to estimate atmospheric conditions, the Mars Global Atmosphere Reference Model (Mars-GRAM), was based on fitting simple functions and theoretical models to the limited observational dataset. The new MCD is formed of meteorological statistics compiled from multi-annual integrations of both GCMs at high horizontal and vertical resolution and with various realistic scenarios for the distribution in time and space of suspended dust, a major cause of interannual variability on Mars. It is hoped that the MCD will be useful both for assessing the Martian environment when planning future missions and for scientific studies of the atmosphere. The MCD will be updated as new observations become available and the models themselves are improved.

A STUDY OF THE MARTIAN DUST CYCLE WITH A GENERAL CIRCULATION MODEL

F. Forget, F. Hourdin and O. Talagrand (Laboratoire de Météorologie Dynamique du CNRS, Paris, France)

The amount of dust which is lifted and transported by the Martian atmosphere is one of the most variable components of the Martian environment, with a strong seasonal cycle, considerable year to year variations and large spatial variations. By its radiative effects, the Martian atmospheric dust plays a major role in determining the climate of the planet.
To improve our knowledge of the dust cycle, and better simulate the related changes in the environmental conditions, we are conducting specific studies using the LMD atmospheric general circulation model. First, we have refined the treatment of the radiative effect of the dust in the model, and studied the impact of the dust on the general circulation. It has been found that during the dustier seasons, the general circulation and the thermal structure are controlled by a quasi-global, inviscid-like, Hadley cell. The existence of such a cell can explains in particular the strong warming of the winter polar atmosphere which was observed by Viking during the 1977-b dust storm. Second, we are now developing a transport model able to simulate the lifting of the dust by the near surface winds, the vertical mixing by the turbulent boundary layer and the atmospheric convection, the advection by the general circulation, and the gravitational sedimentation. Such a model is used to study the mechanisms that control the seasonal cycle and initiate the global dust storms.

SYNCHRONOUSLY ROTATING PLANETS AROUND M STARS AND ATMOSPHERIC COLLAPSE

M. M. Joshi and **R. M. Haberle** (Space Sciences Division (MS 245-3), NASA-Ames Research Center, Moffett Field, CA 94035-1000, USA)

Terrestrial-type planets in the habitable zones of M dwarfs are likely to exhibit synchronous rotation. This means that one side is permanently illuminated and one side is in perpetual darkness. In this situation, atmospheric constituents can condense out on the darkside, and global surface pressures are controlled by the properties of the condensed ice. We show using a simplified general circulation model that horizontal atmospheric heat transport in an atmosphere consisting of approximately 30 mb of CO_2 is sufficient to prevent collapse from taking place. The atmospheric circulation on such planets is then controlled by a combination of the strong synchronous heating as well as their small planetary rotation rate. Darkside surface temperatures are determined by properties such as surface pressure and optical depth. The results bring into question the concept of a habitable zone around M dwarfs that is independent of planetary parameters. The implications of these results on the search for extrasolar planets, especially habitable ones, is discussed.

DEUTERIUM ENRICHEMENT IN GIANT PLANETS.

C. Lécluse, F. Robert (Muséum National d'Histoire Naturelle, Laboratoire de Minéralogie, URA n° 736, 61 Rue Buffon, 75005 Paris, France)
D. Gautier, (DESPA (URA CNRS 264), Observatoire de Paris-Meudon, 5 Place Janssen, 92195 Meudon Cedex, France)
M. Guiraud (Muséum National d'Histoire Naturelle, Laboratoire de Minéralogie, URA n° 736, 61 Rue Buffon, 75005 Paris, France)

The measurement of the isotopic exchange rate constants for a methane-hydrogen mixture was used to calculate f(z), the isotopic enrichment factor between CH_4 and H_2, at every level, in the outer atmosphere of the giant planets. Assuming that the atmospheres are fully convective (Prandl theory), the uncertainties are calculated by error propagation. At z=0 and P=1 bar, the enrichment factors are 1.25±0.12, 1.38±0.15, 1.68±1.23, 1.61±0.21, for Jupiter, Saturn, Uranus and Neptune respectively. The D/H ratio in H_2 was calculated using the f(0) values and the deuterium abundance measured in methane in the planet atmospheres. $(D/H)_{H2}$ in Jupiter and Saturn is close to the protosolar nebula value. On the contrary, Neptune and Uranus exhibit an enrichment in Deuterium relatively to the protosolar nebula, but seem to be depleted relatively to the Standard Mean oceanic Water. In the case of Neptune, results implied that Neptune core was formed by ices containing no interstellar water.

INTERACTION OF SOLAR RADIATION WITH ICE-COATED PARTICLES IN THE MARS ATMOSPHERE

W. J. Markiewicz and **M. W. Wuttke** (Max-Planck-Institut für Aeronomie, Postfach 20, D-37189 Katlenburg-Lindau)

As a model for the morning UV profiles obtained by the KRFM instrument aboard the PHOBOS 2 spacecraft we assume a time evolving, near surface layer of silicate particles covered with water ice. For this model we have already computed the time evolution of temperature and size of individual particles by solving a coupled system of differential equations for these quantities. We extend our model with an equation for the size distribution of the whole aerosol ensemble. From such calculations the optical properties of the aerosol layer and the sublimation rate follow self-consistently. Results will be compared with PHOBOS/KRFM data.

WATER ON MARS AND EARTH

T. Owen (University of Hawaii, Institute for Astronomy, 2680 Woodlawn Drive, Honolulu, HI 96822)

Studies of oxygen and hydrogen isotopes in SNC meteorites together with determinations of D/H in Martian water vapor and in comets offer an opportunity for a fresh investigation into the sources of water on the inner planets. Water from the Shergottites is systematically different from that in Nakhla, possibly revealing a difference between surface and sub-surface reservoirs on Mars. Water from minerals in the SNCs appears to show the influence of cometary impacts on Mars, if the $D/H = 3.2 \times 10^{-4}$ measured in Halley's comet is typical of cometary water. Then ocean water on Earth must contain a major non-cometary component to achieve the observed value of $D/H = 1.6 \times 10^{-4}$. Adsorbed water vapor from the local solar nebula during accretion of the planet appears to be a promising source, given the existence of "solar" neon in the Earth's mantle today.

CORRECTION OF ATMOSPHERIC EFFECTS IN VIKING ORBITER IMAGES

W. J. Markiewicz, N. Thomas, K. Richter, H. U. Keller and **M. W. Wuttke** (Max-Planck-Institut für Aeronomie, Postfach 20, D-37189 Katlenburg-Lindau)

Multiple scattering of solar photons in the Mars atmosphere results in a non trivial contribution to the images of the surface obtained by an orbiting spacecraft. In preparation for the Mars '96 mission we have developped algorithms to correct for this atmospheric effect. These algorithms have been tested on Viking Orbiter images. After the unsuccessful result of the Mars '96 mission we extend the work on Viking data, where this kind of correction hasn't been done systematically. We give an overview over the existent software tools and present results (estimation of opacity, wavelength dependence) for selected sets of color mosaics.

ARE THEY ELECTROSTATIC DISCHARGES IN THE MARTIAN ATMOSPHERE?

O. Melnik and M. Parrot, LPCE/CNRS, 3A, Avenue de la Recherche Scientifique, 45071 ORLEANS Cedex 02, France

Electrostatic discharges in planetary atmospheres is an important phenomena for the evolution of life [Chameides et al., *Nature*, 280, 820-822, 1979]. But on Mars this phenomena is very particular because the Martian atmosphere is tenuous and lightning could not occur. Electrical discharges could only appear in the large dust and sand storms which exist on this planet. Airborne dust is a significant component of the Martian atmosphere. The question arises of whether the movement of dust during Martian storms may be a source of electrification of dust clouds? What is the mechanism of charge separation? Is there a dependence between particle's size and sign of charge? Are potential gradients enough high for breakdown? In summary, Eden [*Electrical Processes in Atmosphere* (edited by H.Dolezalek and R.Reiter), pp.567-573, Steinkopf, Darmstadt, 1977] suggested that Mars presents an atmosphere in which there are clear possible charging mechanisms. Oppositely, Rinnert [*Handbook of Atmospheric Electrodynamics*, Vol. 1, ed. by Hans Volland, CRC Press, Boca Raton, 1995] claimed that it is very unlikely that efficient electrification and charge accumulation to high potentials can occur. The aim of this paper is to perform some mathematical modelling for electrification of dust during large storms in Martian low atmosphere including different considerations. We will give a review on the dust and sand storm electrification in Terrestrian and Martian atmospheres, and discuss the peculiarities of the contact electrification. The particle size distribution function and particle density in the atmosphere of Mars is presented. The motion of dust particles is analysed by Newton's and Maxwell's equations. Mathematical computer simulation of dust particles ensemble moving by the wind is given.

ATMOSPHERIC LOSSES UNDER BOMBARDMENT OF THE COSMIC DUST. INFLUENCE OF DUST BOMBARDMENT ON THE EVOLUTION OF THE PLANETARY ATMOSPHERES.

Anatoly K. Pavlov (Ioffe Physical Technical Institute, Russian Academy of Sciences, 194021, St.Petersburg, Russia).
Alexander A. Pavlov (St.Petersburg State Technical University, Faculty of Physical Science and Engineering, Department of Space Physics, 195251, St.Petersburg, Russia).

We have considered the new process of atmosphere losses -"sputtering" under bombardment by the interplanetary dust . It is demonstrated that atmospheric "sputtering" under collisions with the interplanetary dust is an effective way of the atmospheric gas loss (10^{-4} - 10^{-3} of the accreting dust particles' mass). The atmospheric gas composition is assumed as in the modern Martian atmosphere - the "main" gases in the upper atmosphere are O, CO_2 . The case of hydrogen predominance in the upper atmosphere is also considered. In our computations we pay a particular attention to the abundance of noble gases in planetary atmospheres. We have got that under "sputtering" by the interplanetary dust, atmospheres enrich by the "heavy" elements and isotopes in the wide range of the upper atmosphere parameters (temperature, chemical structure). However the loss efficiency for the "heavy" gases including Xe is relatively high comparing to other known gas loss processes.
In the framework of the new escape process, the main peculiarities of the noble gases abundance in the planetary atmospheres could be explained.

REMOTE SENSING OF WATER IN THE ATMOSPHERE OF SATURN WITH HST AND EVIDENCE OF RING EROSION

Renée Prangé (IAS, Bat. 121, Université Paris-XI, Orsay Cedex, France)
Thierry Fouchet (IAS, Bat. 121, Université Paris-XI, Orsay Cedex, France)
Régis Courtin (DESPA, Observatoire de Paris, 92195 Meudon, France)
Lotfi BenJaffel (IAP, 75014 Paris, France)
Jack E.C. Connerney (NASA/GFSC, Greenbelt, MD 21717, USA)
Keith Noll (STScI, Baltimore, MD 21218, USA)
Jack C. McConnell (York University, Ontario, M3J 1P3, Canada)

The problem of Saturn's ring erosion has been a long standing problem. Following several earlier indirect evidences of the presence of significant amount of water in Saturn's atmosphere, our FUV spectra acquired aboard the Hubble Space Telescope, show unambiguous increase in water influx in the upper atmosphere of the planet at latitudes magnetically conjugate from the rings. At the same time FUV images of the whole planet where taken with the Faint Object Camera aboard HST, allowing for water absorption in the bandpass. HST/WFPC2 images taken close in time in the near UV are subtracted in order to provide a narrower bandpass centered on the water absorption band. The resulting images show enhanced absorption in both hemispheres of the planet, at the locations expected from the magnetic theory of ring erosion. Modeling of the spectra and images can provide an estimate of the water influx as a function of latitude.

DETECTION OF HAZES IN THE NEPTUNE STRATOSPHERE

F. Roques (Département de Recherche Spatiale, Observatoire de Paris, 92195 Meudon, France)

Stellar occultations are sensitive probes of distant planetary atmospheres. They provide information about the dynamical processes at work in the stratosphere, in particular for Uranus and Neptune. The lightcurves always contain sharp intensity variations, indicating that the atmosphere is not isothermal. The comparison of simultaneous observations of occulations have revealed a strong layered structure with axial ratio of $\sim$ 60 for the two planets. The analyse of occultation lightcurves provide also information about the composition and the global shape of the atmosphere.
We have searched possible signature of haze layer in 22 temperature lightcurves of occultation by Neptune observed between 1983 and 1990. Two observations exhibit absorption-like features. One of them is confirmed by the simultaneous observation at different wavelenghts. It is interpreted as an aeros ol layer with a normal optical depth of $\sim 10^{-2}$ at $2.2\mu m$. The observation of a Mie dependance of the optical depth on the wavelenght allows to distinguish between absorption by aerosol and purely thermal structures. This aerosol layer could be connected with haze layers observed by Voyager. The lifetime and possible origine of aerosol layers at such pressure will be discussed.

THE EQUATORIAL ACTIVITY OF SATURN IN 1995 AND 1996

A. Sanchez-Lavega (Univ. Pais Vasco, Bilbao, Spain), J. M. Gomez (GEA, Barcelona, Spain), J. Lecacheux (Obs. Meudon, Paris, France), F. Colas (Bureau Longitudes, Paris, France), I. Miyazaki (Okinawa, Japan), D. Parker (Florida, USA), J. F. Rojas (Univ. Pais Vasco, Bilbao, Spain).

We have performed a regular CCD imaging of Saturn during 1995 and 1996, employing the 1 meter telescope at Pic-du-Midi Observatory in France and 0.4 - 0.6 meter telescopes in Spain, Japan and USA. Complementary observations in the methane bands between 1.7 to 2.3 microns were obtained with the 3.5 meter telescope at Calar Alto Observatory in Spain. These observations revealed the continuous activity of large white spots in the Northern Equatorial Zone (latitudes 5^0N to 15^0N) during 1995. One of them was apparently the large storm system we tracked during 1994 (Sanchez-Lavega et al., *Science*, 271, 631, 1996) suggesting a lifetime > 1 year for this feature which moved with a steady zonal velocity of ~ 275 ms^{-1}. This activity influenced the North Equatorial Belt at 20^0N which showed in the best images ondulated structures reminiscent of a wave-dynamical phenomena with a wavenumber 18. We were unable to detect this activity during 1996. However the Southern Equatorial Zone was very active during this year with the development of white and bright spots centered between latitudes 9^0S and 14^0S. Some of them were persistent (lifetime > 3 months) and tracking of their motions gave velocities ranging from 263 to 284 ms^{-1}. All this suggest that disturbances in Saturn's Equator are still present after the great outburst of September 1990 .

THE INTERACTION OF MARS WITH ITS ATMOSPHERE

David E. Smith (NASA Goddard Space Flight Center, Greenbelt, Maryland 20771, USA)
Maria T. Zuber (Massachusetts Institute of Technology, Cambridge, Massachusetts, 02139. USA)

Motions within the atmosphere of Mars cause small but measurable effects on the gravity field and dynamics of Mars. We have used the NASA Ames General Circulation Model (GCM) to estimate the magnitude of these effects on Mars for a typical Mars year. Mean atmospheric conditions were used for each 33 days and using a recent geopotential topography model in the GCM we derived the pressure field. precipitation and wind fields over the surface of Mars and calculated their effect on the low degree terms of the gravity field, the length of the Martian day, and the position of the pole of rotation. Approximately 25% of the CO2 in the Mars atmosphere moves from one pole to the other as the seasons change, some of it condenses out as ice forming an additional mass layer on the surface, thus increasing the mass at the winter pole at the expense of mass at the equator and the summer pole. This mass re-distribution changes the gravitational (dynamic) flattening (J2) and the "pear shape" (J3) terms in the gravity field of Mars. Our preliminary analysis of the magnitudes of these effects indicates precipitation at the winter pole is the single most important effect on the gravity field and winds the most important effect on the rotation of Mars.

Martian atmospheric chemistry: Consequences of H:O escape ratio

W. Stumptner*,+, H. Lammer*, S.J. Bauer*,+ (Space Research Institute, *Austrian Academy of Sciences, Graz, and +Institute for Meteorology and Geophysics University of Graz, Austria)

Current models of martian atmospheric chemistry use simplifications based on the assumption of a ratio of 2:1 for the ratio of H:O loss to space. This ratio - although stoichiometricly justifiable - has been shown not to hold by our recent work, which found it to be 12:1. We will present some consequences of this result for the current understanding and modelling of Martian atmospheric chemistry.

ZONAL DIFFERENCES OF THE ATMOSPHERIC STRUCTURE ON SATURN FROM THE CCD-PHOTOMETRY AND SPECTROPHOTOMETRY IN 1995 AND 1996

V.G.TEJFEL, G.A.KHARITONOVA (Fessenkov Astrophysical Institute, Alma-Ata. 480068 Kazakhstan. tejf@afi.academ.alma-ata.su)

In 1995 and 1996 the observational conditions were especially favorable for the comparative study of the optical properties of both (Northern and Southern) hemispheres of Saturn when the Earth crossed Saturn's ring plane or had a small declination angle. Many hundreds of good images and spectra of Saturn were obtained with 1-meter and 60-cm telescopes and CCD-camera ST-6V. The intensities of several methane absorption bands (from 619 nm to 887 nm) were measured on the spectra of the central meridian of Saturn. The same was done for two series of 16 zonal spectra that were used for obtaining of the detailed picture of the methane absorption distribution on entire Saturn's disk. All data showed a significant North-South asymmetry for the methane absorption values as well as for zonal limb darkening coefficients, derived from the photometry of the good quality CCD-images of Saturn. The maximum of the methane absorption lies in the Northern hemisphere on high latitudes decreasing toward the equator. The equatorial region shows minimal absorption as it was observed earlier too. In the Southern hemisphere the methane absorption increases toward high latitudes but smaller than in the Northern hemisphere. The similar latitudinal differences characterized the limb darkening coefficients in the continuum spectrum but by inversed manner: the smaller limb darkening is observed on Northern latitudes and increased sharply approximately on 0.2 in the red light toward the equator (on the latitudes less +30 deg where the limb darkening is maximal) and in the Southern hemisphere where some latitudinal oscillations of it are expressed noticeably. These latitudinal differences of the optical characteristics must be considered as an evidence of the differences in the atmospheric structure and asymmetry of the processes in the Northern and Southern hemispheres of Saturn. Probably this asymmetry is keeping from the preceding time of unhomogeneous insolation of hemispheres.

SPATIAL VARIATIONS OF THE ATMOSPHERIC WATER VAPOUR ON MARS FROM THE *ISM /PHOBOS-2/* IMAGING SPECTROMETRY

D.V. Titov (Space Research Institute, 117810 Moscow, Russia)
P Lampen and G. Arnold (Institute for Planetary Exploration, DLR, 12489 Berlin, Germany)

Spectral imaging of the equatorial region of Mars was carried out in the *ISM /Phobos-2/* experiment. The maps of spatial distribution of the atmospheric water vapour were obtained from the measurements in the 1.87 μm and 2.56 μm spectral bands. The spatial variations of H_2O mixing ratio reach a factor of 3. Enhanced H_2O mixing ratio was found above the cones of Olympus and Ascraeus Mons, the slopes of Tharsis Plateau west from Pavonis Mons, west from Hebes Chasma and in some other regions. Diurnal variations up to a factor of 2 were found from the observations of Pavonis Mons region in the morning and at noon. The *ISM* spectra were corrected for the presence of the absorption signatures of atmospheric gases: CO_2, H_2O and CO, that allows one to study the variations of weak spectral features of the surface origin. An attempt to search for correlation between the atmospheric water amount and regolith spectral properties was made.

SPEEDRESONANCE WAVES IN THE ATMOSPHERES OF THE TERRESTRIAL AND OUTER PLANETS

Victor P. Vasilyev and Vladislav A. Sergeev (Institute of Radio Astronomy, 4 Chervonopraporna Str., Kharkiv, 310002, Ukraine)

General approach to the speedresonance gas-dynamic wave generation by moving with the near-sound speed thermal sources in the atmospheres of Earth, Mars, Jupiter and Saturn is presented. Within the Terrestrial and Martian atmospheres such sources exist in the solar terminator regions. Three-dimensional analytical model for these phenomena is investigated. The model analysis showed that the solar terminator is an effective generator for the speedresonance acoustic and surface quazimonochromatic waves with the relative amplitudes of pressure/density/gas velocity at least the order of 10^{-6} and 10^{-4} for the Earth and Mars, respectively. The like mechanism can true for the Jovian and Saturnian atmospheres within the zones of total solar eclipses by the largest satellites. Seasonal, latitudinal and height dynamics and peculiarities are analyzed. Connection with the observed and some of the new non-stationary terminator and shadow effects is discussed.

LONG-TERM EVOLUTION OF VENUS GLOBAL ENVIRONMENT

T. Widemann

Like global terrestrial environmental changes, Venus atmosphere is affected by long-term astronomical properties of the inner solar system: solar long-term evolution, interstellar and zodiacal dust interaction, and secular orbital and dynamical changes. Solar cycles and solar luminosity long-term evolution affect UV radiative transfer and related photochemistry in the upper atmosphere. Partial screening of solar radiation by local interstellar matter and optical thickness changes in zodiacal cloud cause cooling of Venus and other telluric planets. Obliquity, excentricity and inclination variations in Venus orbit may change patterns of global atmospheric circulation and torque-driven hyper-rotation. On Venus, orbital changes are calculated under the same planetary theory as for the Earth - a resolution of coupled Lagrangian equations which provide long period terms for excentricity and inclinations in the disturbing function. Seasonal effects are poorly marked along Venus low excentricity orbit. However, in long orbital variation terms, episods of higher excentricity would change gravitational torque amplitude on the atmosphere due to Sun distance variation and possibly change the thermal tide hyperrotation regime.

INVERSE PROBLEMS OF SOUNDING THE PLANETARY ATMOSPHERES FROM LANDER SPACECRAFT IN SOLAR AND THERMAL IR SPECTRAL REGIONS

E. Ustinov (Cornell University, Ithaca, NY 14853, USA)

The inverse problems of interpretation of the downward radiation measured at the bottom of the planetary atmosphere from the lander spacecraft are considered. A comparison to analogous, more traditional, inverse problems of interpretation of the outgoing radiation emerging from the top of the planetary atmosphere is made. Two specific inverse problems formulated for interpretation of the downward radiation measurements are considered and their practical applications, in particular, to studies of the boundary layer of the planetary atmosphere are discussed.

AN EOF DIAGNOSTIC STUDY OF A MARTIAN GLOBAL CIRCULATION MODEL

S. G. Whitehouse and I. M. Moroz (OCIAM, Mathematical Institute, Oxford University, 24-29 St Giles, Oxford, England, OX1 3LB)
M. Collins, S. R. Lewis, P. L. Read (Atmospheric, Oceanic and Planetary Physics, Clarendon Laboratory, Parks Road, Oxford, England, OX1 3PU)

Our aim is to seek a low-dimensional description of baroclinic instability in general and of the Martian atmosphere in particular, where both forcing and spatial resonance are relevant to the dynamics of the system being analysed. Empirical Orthogonal Functions (EOFs) will be used to determine a basis for the modal decomposition of climate simulations of Mars obtained using two General Circulation Models: (a) an idealised model in which the meteorological primitive equations are solved on a sphere with simplified physical parameters and (b) a more realistic model in which a comprehensive range of the relevant Martian physical parameters and topography are represented. The results of these analyses will be presented for a range of Martian seasons and climatic conditions, and we will discuss possible physical interpretations of the identified modes. We will also consider the effects of using different forms of energy norm in performing the analysis, with the objective of providing analyses which represents the physically most significant components of the circulation with optimal efficiency.

PS4 Titan's atmosphere and surface: recent developments

Convener: Coustenis, A.
Co-Convener: Taylor, F.W.

Sponsorship: ICPAE (International Commission on Planetary Atmospheres and their Evolution), ESA, COSPAR, UAI, IAA (International Academy of Astronautics)

ATMOSPHERIC COMPOSITION OF TITAN

B. Bézard (Observatoire de Paris, Section de Meudon, F-92195 Meudon, France)

A great deal of what is known today on Titan's atmosphere originates from the Voyager 1 mission in 1980. Refined analyses of the Voyager infrared spectra allowed to establish the stratospheric composition of Titan as a function of latitude, and provided more precise information on the concentration profiles of the main constituents (N_2, CH_4, H_2, Ar?). Pronounced latitudinal variations were observed for several compounds (nitriles and some hydrocarbons), likely due to seasonal effects. These variations, along with the asymmetry observed in the haze characteristics, strongly affect the radiative balance of the atmosphere. Ground–based spectroscopy in the near–infrared and more recently in the 5–μm window allowed the detection of carbon monoxide and provided constraints on its tropospheric abundance. Millimeter heterodyne observations led to the first detection of acetonitrile (CH_3CN) on Titan. Observations of rotational lines from CO, HCN, and HC_3N provide unique information on the disk–averaged vertical profiles of these species. All these different pieces of information form a picture of Titan's atmosphere in which a complex photochemistry is at work, ruling the formation of clouds and hazes, and affecting the temperature field and possibly the dynamics, through still poorly known processes. Progress may be expected from ISO spectral measurements in 1997, further ground–based observations, and obviously from the Cassini–Huygens mission on the eve of the next century.

THE CASSINI/HUYGENS DOPPLER WIND EXPERIMENT

M. K. Bird, R. Dutta-Roy and M. Heyl (Radioastronomisches Inst., Universität Bonn, 53121 Bonn, Germany)
M. Allison (NASA-GISS, New York, NY 10025, USA)
D. H. Atkinson (Dept. Elec. Engg., U. Idaho, Moscow, ID 83843, USA)
S. W. Asmar, W. M. Folkner and R. A. Preston (NASA-JPL, California Inst. of Technology, Pasadena, CA 91109, USA)
P. Edenhofer, D. Plettemeier and R. Wohlmuth (Institut für HF-Technik, Universität Bochum, 44780 Bochum, Germany)
L. Iess (Dipart. Aerospaziale, U. Roma 'La Sapienza', 00184 Roma, Italy)
G. L. Tyler (Center for Radar Astron., Stanford U., Stanford, CA 94305, USA)

The primary scientific objective of the Doppler Wind Experiment New mail on node LINAX1 from SMTP(DWE) is to determine the velocity of Titan's zonal winds from the beginning of the Huygens atmospheric descent (altitude ~160 km) down to the surface. The Probe's wind-induced motion will be derived from the residual Doppler shift of its S-band radio link to the Cassini Orbiter, corrected for all known orbit and propagation effects. The frequency of the Probe signal will also be recorded with large ground-based antennas, thus providing another component of the horizontal drift. DWE will obtain valuable ancillary information on the rotation, parachute swing and atmospheric buffeting of the Huygens Probe, as well as its final place of rest on Titan. Experiment status 6 months from launch, as inferred from the DWE pre-launch test program, will be described.

COLD PLASMA SIMULATION OF TITAN'S AEROSOLS AT LOW TEMPERATURE

P. COLL, D. COSCIA, M-C. GAZEAU & F. RAULIN (LISA, Universités Paris 7, Paris 12 & C.N.R.S, C.M.C., 61 av. du Général de Gaulle, 94010 Créteil cedex, France).

The atmosphere of Titan -mainly made up of N_2 and CH_4, and including many organics- consists partly as well of *hazes and aerosol particles* which shroud the surface of the satellite and gives its reddish outlook appearance. To reproduce in the laboratory the photochemical synthesis of these aerosols at high altitudes, and to study their formation processes and composition, « a Titan's aerosol generator » was developed. Titan's aerosols were thus produced under conditions similar to Titan's atmosphere (cold plasma energy source, pressure < 3 mbar and temperature < 200 K). A systematic protocol was used as well to allow the formation, the recovery and the analysis of these aerosol analogues in conditions free of contamination. So far, the available samples most representative of Titan's atmosphere were analyzed using different techniques . The elemental composition, molecular weight, structure with number and size of particles... were thus obtained and are presented here. Our next goal consists in measuring the optical constants of these aerosol models.

Finally, in the frame of the Cassini-Huygens Mission, it will be of crucial importance to re-examine the numerous data of Titan's observation, in the light of these new laboratory results.

TITAN'S SURFACE FROM ADAPTIVE OPTICS IMAGING

M. Combes and A. Coustenis (DESPA, Observatoire de Paris-Meudon)

Titan's images were acquired with the ADONIS adaptive optics system installed at the ESO Telescope in La Silla (Chile). The near-infrared range from 1-2.5 micron was covered in 1994, 1995 and 1996, including methane atmospheric windows at 1.3, 1.6 and 2 micron with narrow-band filters and CVF. The images are diffraction-limited and allow to resolve Titan's disk. We have applied deconvolution processes and corrected for systematic errors and center-limb effects. The contrast is of the order of 30%. Both the leading and the trailing hemispheres have been observed.

The 2-micron images show on Titan's leading hemisphere a broad bright equatorial region near 114 degrees longitude, in accordance with the HST images (Smith *et al.*, 1995) and with spectroscopy performed at these longitudes (Coustenis *et al.*, 1995; 1996). High-quality flat-fielding of our data has allowed us to resolve the bright region into several (2-3) poles.

On the trailing hemisphere of Titan is not completely dark, but shows bright features near the poles, with a pronounced North-South asymmetry. The high northern latitudes are uniformly brighter than the lower equatorial and southern ones.

We will present our images of Titan and offer some constraints on the nature of the surface features.

HIGH RESOLUTION IMAGING OF TITAN WITH ADAPTIVE OPTICS IN THE NEAR-INFRARED

M. Combes, A. Coustenis, L. Vapillon, E. Gendron, R. Wittemberg, R. Sirdey and J-P. Veran (DESPA, Paris-Meudon Observatory)

We have taken new spatially-resolved images of Titan in the near-infrared range with the ADONIS adaptive optics system at the ESO Telescope in La Silla (Chile) in October 1995 and November 1996. Both the leading and the trailing hemispheres have been observed from 1.6 to 2.5 micron with high signal-to-noise ratio and a contrast of about 30%.

We have used both narrow-band filters in the center and the wings of the methane windows and CVF. We will present our new data and discuss the constraints they offer on the nature of the surface features present on Titan's leading and trailing hemispheres' surfaces.

MODELLING TITAN'S SURFACE FROM NEAR-IR FTS/CFHT 1995-96 SPECTRA

A. Coustenis, E. Lellouch and R. Wittemberg (DESPA, Paris-Meudon Observatory, FRANCE)
J-P Maillard (IAP, Paris)
C. P. Mckay (NASA/AMES)

Titan's surface has been investigated in 1995 and 1996 using the FTS at the CFHT in the near-infrared range (0.7-2.5 μm). This data extend previous observations since 1991 and give a complete lightcurve over Titan's orbit in the methane windows, showing a bright leading and a lower-albedo trailing hemisphere, in accordance with previous findings. Modelling of the surface spectrum allows to constrain its nature and the components which could be present. Thus, Titan's spectrum shows two regions: a bright part near 1 μ and a darker one (by a factor of about 2.5) from 1.5 to 2 μm. The latter is compatible with the water ice absorption bands at 1.52 and 2.02 μm, present at all longitudes over the disk. The overall high albedos that we find are compatible with the presence of tholin material on the surface. Tholins, water ice and liquid hydrocarbons alone cannot however explain the longitudinal variations of the surface brightness. Titan images show that bright regions exist on Titan's leading hemisphere that could be responsible for the albedo increase. We have simulated the presence of a mountain to explain this morphology. We find that a surface relief, no matter how high, can not account for the total observed hemispheric asymmetry, even when associated with a large cloud opacity. An additional component is required to satisfy the data.

OBSERVATIONS OF TITAN WITH THE ISO SATELLITE

Th. Encrenaz, A. Coustenis, E. Lellouch and D. Gautier (DESPA, Observatoire de Paris, F-92195 Meudon, France)
A. Salama and M. F. Kessler (ISO Science Operating Center, Villafranca, E-28080 Madrid, Spain)
Th. de Graauw (SRON, Groningen, NL-9700 AV, The Netherlands)
M. J. Griffin (QMW College, London E1 4NS, UK)
G. Orton (JPL, Pasadena, CA 91109, USA)

The european satellite ISO (Infrared Space Observatory), launched in November 1995, is dedicated to the infrared observation of the sky by imaging, photometry and spectroscopy. Two spectrographs cover the 2.3-180 μm range with a resolving power ranging from 100 to 2000 (grating modes) and the 11.4 - 180 μm with a resolving power of 10000- 30000 (Fabry-Perot modes). Observations of Titan are planned in January 1996. The spectral resolution should be about 5-10 times better than the IRIS-Voyager spectra, and the sensitivity is expected to be better than 1 Jy. Synthetic calculations have been performed by Coustenis et al. (Icarus, 102, 240, 1993). In the thermal range (above 7 μm), expected emission features include all the hydrocarbons and nitriles previously detected by the IRIS spectrometer. In particular, the ISO data should allow to fully resolve the C_4H_2 and C_3H_4 bands around 16 μm. Rotational lines of HCN, CO and CH_4 are expected to be detected in the far infrared range. Other possible candidate molecules include H_2O, C_3H_4 (allene) and C_6H_6 (benzene).

AERODYNAMICS SIMULATIONS IN DEVELOPING THE HUYGENS ATMOSPHERIC PRESSURE PROFILE INSTRUMENT

B. Fagerström (Lab. of Aerodynamics, Helsinki Univ. of Technology)
T. Siikonen (Lab. of Applied Thermodynamics, Helsinki Univ. of Technology)
A.-M Harri (Geophysical Research Division, Finnish Meteorological Institute)

Numerical simulations were performed to determine the flowfield around the Huygens probe during its descent in the Titan atmosphere. The simulations were needed in developing the pressure profile instrument (PPI) for the Huygens Atmospheric Structure Instrument (HASI).
The simulation work encompassed solving the Reynolds-averaged Navier-Stokes equations in 3-dimensional and 2-dimensional grids by using the FINFLO code developed at the Helsinki University of Technology. In turbulent cases the Baldwin-Lomax turbulence model was used.
The simulation of the flowfield around the Huygens probe revealed that local Mach number varies 10 to 20 percent on the side of the spacecraft depending on variations in the spacecraft's attitude. A comparison of a static pressure probe versus a total pressure probe with conversion to static pressure based on a Mach number obtained from other measurements resulted in a ratio of 2 to 1 in flow related uncertainty. Hence, it was decided to use a pitot tube measuring the total pressure as the pressure measurement probe.
Due to the spacecraft's attitude variations a probe design with high insensitivity to the flow direction was required. A Kiel type shielded design, modified to reduce weight, was selected to give a correct total pressure up to 45 degrees incidence. This was verified by flow simulations and wind tunnel tests.

CHEMISTRY AND PHYSICS OF PHOTOCHEMICAL AEROSOL FORMATION IN TITAN'S ATMOSPHERE.

V.Dimitrov and A. Bar-Nun (Department of Geophysics and Planetary Sciences, Tel-Aviv University, Tel-Aviv, Israel)

The general scenario and a physico-chemical model of aerosol formation in Titan's atmosphere are developed. The scenario consists of the following main stages : the inception of gaseous individual molecules of aerosol substance at the altitude $Z \sim 950\ km.$ and their further association into big friable conglomerats ("liquid drops"). The maturation of the latter is a very limp process in the altitude range $Z \sim (950 - 650)\ km.$, following which, begins the nucleation and transformation of the "liquid drops" into primary embryos, representing the smallest condensed regular spheres $R \sim (5 - 8) \cdot 10^{-10} m$. From this time on, the abundance of gaseous aerosols is continuously decreasing, while the amount of condensed phase is steadily increasing, untill their quantities become comparable. This occures at $Z \sim (510 - 540)\ km.$ The primary embryos grow through condensation and collision mechanisms, resulting in the formation of big objects of non-regular shape, which slowly fall through Titan's atmosphere. Chemical kinetic, physical and gasdynamic circumstances are the point of issue and a number of items are worth commenting upon. We found that the aerosols are composed of higher hydrocarbons, such as Polyacetylenes, Vinylacetylenes and Polyvinyles up to C_{60}. The average life-time of an evolving aerosol speciesentity does not exceed $\sim (0.9 - 1.3) \cdot 10^{14}$ sec. Total concentration of stationary airbone condensed mass lies within the range $\sim (0.8 - 1.7) \cdot 10^{-9} g/m^3$.

CASSINI UVIS TITAN SCIENCE OBJECTIVES AND OBSERVATIONS

L.W. Esposito, Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO 80309-0392 USA

The Ultra-Violet Imaging Spectrograph (UVIS) is part of the remote sensing payload of the Cassini Orbiter. The UVIS has two spectrographic channels which provide images and spectra in the range 56 to 118 nm and 110 to 190 nm. A third optical path with a solar blind CsI photocathode is used for high SNR stellar occultations by rings and atmospheres. A separate Hydrogen-Deuterium Absorption Cell (HDAC) measures the relative abundance D/H from their Lyman-alpha emission. The UVIS will image Titan's clouds in the UV, providing latitutidinal information on cloud height, size distribution and composition. Limb scans will detect hazes and cloud-top vertical structure. Spectra, alongwith stellar and solar occultations, will determine the horizontal and vertical distributions of methane, ethane, acetylene and other hydrocarbons. Neutral emissions will quantify the thermospheric energy balance and interactions with the Saturn magnetosphere. The hydrogen torus will be mapped by regular system scans of the entire Saturn-rings-Titan-magnetosphere system. The HDAC will measure the D/H ratio. In combination with other in-situ and remote sensing Cassini experiments, we will define the clouds, chemistry, energetics, evolution and interactions of Titan's upper atmosphere.

THE DYNAMIC METEOROLOGY OF TITAN

F. M. Flasar (NASA/Goddard Space Flight Center, Greenbelt, MD 20771 USA)

Knowledge of Titan's zonal winds derives from temperatures retrieved from Voyager infrared measurements and geopotential heights retrieved from stellar occultation observations. The inferred stratospheric winds are cyclostrophic. General circulation models of Titan's winds are still in their infancy, but suggest much of the troposphere must be stably stratified, so that the cyclostrophic zonal winds aloft are isolated from surface drag. The vertical structure of temperature, above the lowest $\sim$ 4 km, is consistent with a radiatively balanced atmosphere. However, moist convection could still be very efficient, and updrafts covering only $< 10^{-5}$ of the surface area can balance the flux of sunlight absorbed at the surface. Despite the short radiative relaxation time, the temperatures in the upper stratosphere observed by Voyager at the northern spring equinox exhibited a curious north-south asymmetry. This may be partly attributable to opacity variations, but the implied asymmetry in the seasonally varying zonal winds requires a cross-equatorial Lagrangian circulation to transport angular momentum and heat to maintain the thermal wind balance. The appearance of a well-defined circumpolar ring at 70° N in Voyager images, implying the existence of a stable polar vortex, and the observed enhancement of nitriles and some hydrocarbons in the north polar region suggest that Titan may have its own analog to the ozone hole. We conclude with a summary of the Cassini observations of winds, temperatures, and trace constituents that will transform our conceptual understanding of Titan's atmospheric circulation.

THE HASI EXPERIMENT: INVESTIGATION IN TITAN'S ENVIRONMENT

M. Fulchignoni (Univ. Paris 7 - DESPA, Obs.Meudon); F.Angrilli, G.Bianchini, F. Ferri (CISAS-Univ. Padova); R.J. Grard (SSD-ESTEC), M. Hamelin (LPCE), A.M. Harri, (FMI), G.W. Leppelmeier (FMI), J.J. Lopez-Moreno (IAA), J.A.M. McDonnell (UKC), R. Rodrigo (IAA), C. Schwingenschuh (IWF), H. Svedhem (SSD-ESTEC), J. Zarnecki, (UKC).

The Huygens Atmospheric Structure Instrument (HASI) is one of the six experiments composing the payload of the ESA Huygens probe in the Cassini mission. It is aimed to the definition of the density, pressure and temperature profiles, to study winds, turbulence and electric properties of Titan's atmosphere. HASI is the only working instrument during the probe entry phase, during which indirect information about density, pressure and temperature will be derived from the accelerometer data. The measurements performed during the descent of Huygens probe throught Titan's atmosphere will contribute also to the definition of the probe trajectory, the analysis of the atmospheric composition, the study of the ionization processes and electric fields, detection of lightning and acoustic noise due to turbulence and thunders. Moreover HASI data will provide information for the characterization of Titan's surface, whatever its phase, solid or liquid.

HUYGENS ATMOSPHERIC STRUCTURE INSTRUMENT ON THE CASSINI-HUYGENS MISSION

M. Fulchignoni (Univ. Paris 7- DESPA, Obs.Meudon); F.Angrilli, G.Bianchini, F. Ferri (CISAS-Univ.Padova); E. Flamini (ASI); F. Boldrini, M. Cosi (OG); G.W. Leppelmeier, A.M. Harri, A. Lehto (FMI); R.J. Grard, H. Svedhem (SSD-ESTEC); M. Hamelin (LPCE); C. Schwingenschuh, P. Faulkner, I. Jernej (IWF); R. Rodrigo, J.J. Lopez-Moreno, V. Brown (IAA); J.A.M. McDonnell, J. Zarnecki, H. Jolly (UKC).

The Huygens Atmospheric Structure Instrument (HASI) is a multisensor package which has been designed to measure the physical quantities characterizing Titan's atmosphere in the framework of Cassini-Huygens mission.

The experiment is divided in four subsystems: the accelerometers (ACC); the deployable booms system (DBS); the stem carrying the temperature sensors, a Kiel probe for the pressure measurements and acoustic sensor (STUB) and the data processing unit (DPU). The scientific measurements are performed with four sensors packages, namely the accelerometers (ACC), the Pressure Profile Instrument (PPI), the temperature sensors (TEM) and the Permittivity, Wave and Altimetry package (PWA). The HASI experiment, the principles of operations of the subsystems and their capabilities are described.

A FRACTAL ANALYSIS OF TITAN'S IR CARTOGRAPHIC ALBEDO, IMPLICATIONS FOR SURFACE HETEROGENEITY

J.R.C. Garry (Unit for Space Sciences and Astrophysics, University of Kent at Canterbury, England)
G. Landini (Unit for Oral Pathology, Birmingham University, England)
J.C. Zarnecki (Unit for Space Sciences and Astrophysics, University of Kent at Canterbury, England)

The surface of Titan is obscured by an optically thick particle-rich atmosphere that does not allow visible-light observations to be made of the surface. At IR wavelengths the continuum scattering from these stratospheric acrosols is weakened and within particular windows in methane's absorption spectrum the surface can be sensed. Although the resulting images have little contrast, features on the moon's disc have been seen at relatively high confidence levels. With pictures taken by two different systems these features have been subjected to a fractal analysis technique in an effort to determine the extent to which features can be differentiated from the surrounding background. Images from the HST and ADONIS telescope systems have been processed to determine the fractal dimension of Titan's albedo at scale distances of around 500 km and upwards. The same analysis technique has also been applied to albedo maps of regions on solar system bodies to indicate the confidence with which planetary features may be distinguished on the basis of their cartographic shape. The topological differences between various regions in the images of Titan are described and implications for the heterogeneity of Titan's surface are presented.

ISOTOPIC RATIOS IN TITAN: IMPLICATIONS ON THE ORIGIN OF THE ATMOSPHERE

D. Gautier (Observatoire de Paris-Meudon, 92195 Meudon, France)

Two isotopic ratios have been presently detected in the atmosphere of Titan: the $^{12}C/^{13}C$ ratio from millimetric emission lines of HCN, the D/H ratio from infrared emission or absorption lines of CH_4. We show that the atmosphere must have been mainly formed by outgassing from the interior and that, accordingly, the methane ices (or clathrates) which contributed to forme the satellite, exhibited isotopic ratios similar to those observed in the atmosphere. The D/H ratio in CH_4 is then a tracer of physico-chemical conditions which occurred in the subnebula of Saturn. We have elaborated new temperature-pressure models of the subnebula for various values of the coefficient of turbulent viscosity Alpha. They permit us to show that, CO is converted into CH_4 at the location of Titan for an appropriate value of the coefficient, but that the conversion of N_2 into NH_3 cannot occur, whatever the value of Alpha. These results provide new constraints on the composition and the structure of the interior of Titan. The models of the subnebula lead to a deuterium enichment in methane present in the Saturn subnebula consistent with the the most recent value measured in the atmosphere of Titan.

HIGH-RESOLUTION INFRARED IMAGES OF TITAN USING SPECKLE INTERFEROMETRY WITH THE KECK TELESCOPE

D. Gavel, S. Gibbard, B. Macintosh and C. Max (Lawrence Livermore National Laboratory)
I. de Pater (University of California, Berkeley)
A. Ghez (University of California, Los Angeles)

We used the facility near-infrared camera (NIRC) in speckle mode on the 10 meter W. M. Keck Telescope to observe Titan's surface through its atmospheric windows in H (1.49-1.82 μm) and K' (1.96-2 29 μm) bands. The speckle interferometry technique provides a means of achieving high resolution images from ground-based telescopes. At Keck, the speckle technique achieved spatial resolution near the diffraction limit of the Keck 10-meter aperture, which is 0.05 arcseconds or approximately 300 km on the surface of Titan. With two nights of imaging (June 27 and September 6, 1996) we have been able to form maps over two hemispheres of Titan, corresponding roughly to the greatest western elongation and the greatest eastern elongation faces. The contrast ratio (ratio of flux from lightest to darkest surface regions) approaches 30% in the K band images. From these images it is clear that the brightest surface features lie on the leading (greatest eastern elongation) side, which is consistent with HST maps at shorter wavelengths. The atmospheric limb brightening in these windows, which partially probe the atmosphere as well as the surface, is most prominent in the southern hemisphere. Work performed under the auspices of the U. S. Department of Energy by the Lawrence Livermore National Laboratory under contract number W-7405-eng-48.

EXPERIMENTAL PHOTOCHEMICAL STUDY OF CATALYTIC DISSOCIATION OF METHANE BY THE PHOTOLYSIS OF ACETYLENE AT 185 NM

M.C. GAZEAU, A. KHELIFI, N. SMITH and F. RAULIN (LISA, Universités Paris 7, Paris 12 & CNRS, C.M.C., 61 av. du Général de Gaulle, 94010 Créteil cedex, France).

Photochemistry plays an important role in the chemical structure and evolution of Titan's atmosphere. Methane photochemistry can explain the presence of most of hydrocarbons in this atmosphere. Short wavelength photons ($\lambda < 150$ nm) can directly photolyse methane in the mesosphere (above 500 km). At lower altitude, in the stratosphere, a catalytic scheme for methane dissociation involving acetylene has been proposed. The photons which are present in this atmospheric region ($\lambda < 200$ nm) can dissociate C_2H_2 and the resulting radicals can react with CH_4 giving the CH_3° radical and reforming C_2H_2. This catalytic scheme is systematically used in theoretical modelling to explain C_2H_6 formation in the stratosphere. However, it has never been tested experimentally. That is the aim of our work. An experimental study is being performed on the catalytic scheme by gas chromatographic analysis of the products of the irradiation of a CH_4/ C_2H_2 (1000/1) gas mixture by a Mercury lamp. In parallel, we are investigating the kinetics of this system with the aid of theoretical modelling.

OBSERVING TITAN WITH ADAPTIVE OPTICS : HOW SEEING CONDITIONS CAN DETERMINE DATA QUALITY

E. Gendron, M. Combes, A. Coustenis, L. Vapillon and R. Wittemberg (Observatoire de Paris-Meudon, DESPA, 92195 MEUDON Cedex, France)

Observations of Titan were performed using the "modal control optimization" functionnality of ADONIS. This functionnality aims to recover the best possible image by optimizing the spatial and temporal parameters of the servo-loop correction of the adaptive optics system, in terms of the observing conditions. Starting from the particular example of data acquired in November 1996, the article focuses on the way the modal control could optimize the image quality versus the seeing conditions. The goal of the observations was to spectro-image the surface and lower atmosphere. As this involves manipulation of data taken at different wavelengths and different observing conditions, the mixing of the data with variable characteristics is discussed. The shape of the point spread function is a key parameter in this study, and its impact on the data reduction (signal to noise ratio, deconvolution) and the final quality of the results is adressed.

SURFACE WAVES ON TITAN: ROUGH RIDE FOR HUYGENS?

N.A-L. Ghafoor (Unit for Space Sciences and Astrophysics, University of Kent, United Kingdom)
J.C. Zarnecki and S.F. Green (Unit for Space Sciences and Astrophysics, University of Kent, United Kingdom)
M.A. Srokosz and P.G. Challenor (Southampton Oceanography Centre, Southampton University, United Kingdom)

Several models of Titan invoke the existence of liquid hydrocarbon reservoirs in one form or another. Where these are exposed at the surface, atmospheric interaction may give rise to wind-driven surface waves. This paper firstly considers the currently preferred surface models and tropospheric wind estimates and deduces the properties of the surface waves resulting in each case. Notable in this improved treatment is the consideration of liquid bodies of finite depth and finite extent, particularly significant in light of refined expectations concerning conceivable impact locales. The paper also considers the overall capability of the Huygens instrument suite, firstly in characterising surface waves prior to, during, and after impact and, secondly, in reconstructing the probe's motion following a landing on a liquid surface.

INTERACTION OF TITAN'S ATMOSPHERE WITH SATURN'S MAGNETOSPHERE: A 3D MULTISCALE MHD SIMULATION

T.I. Gombosi, D.L. DeZeeuw, K.G. Powell and K.S. Kabin (The University of Michigan, Ann Arbor, USA)

The results of our 3D multiscale MHD model describing the interaction of Saturn's magnetosphere with Titan's upper atmosphere and exosphere are presented. The effects of a conducting ionosphere, exospheric mass loading and a possible intrinsic magnetic field are taken into consideration. The equations of ideal magnetohydrodynamics are solved using a modern shock-capturing numerical technique. This method is applied on an adaptively refined unstructured grid. The combination of the adaptive refinement with the MUSCL-scheme allows detailed modeling of the near Titan region, while still resolving both the upstream region and the satellite's wake.

Modeling of phase changes in Titan's lower atmosphere

L. GUEZ, P. BRUSTON and F. RAULIN (LISA, Universités Paris 7, Paris 12 & CNRS, C.M.C., 61 av. du Général de Gaulle, 94010 Créteil cedex, France).

The uncertainty about possible supersaturation of methane, condensation of volatile species and the existence of clouds in Titan's lower atmosphere affects our understanding of photochemistry, the nature of the surface and the atmospheric thermal structure. We investigate phase changes of low-molecular-weight species by way of progressively elaborate models. The most simple model takes into account gas eddy diffusion, aerosol settling and phase change, assuming no supersaturation. Description of nucleation seems to be one of the first improvements which should be included in a model of phase changes. The suspicion of difficult methane nucleation comes from analysis of Voyager IRIS spectra. Moreover, species are expected to condense to the solid phase, which excludes very efficient nucleation and condensation processes associated with the presence of a liquid phase, such as deliquescence. We use the classical theory of heterogeneous nucleation which, despite its deficiencies, is employed in atmospheric models, owing to its general nature and relative simplicity.

STRATOSPHERIC CO, HCN, AND HC_3N ON TITAN

M. A. Gurwell (Harvard-Smithsonian Center for Astrophysics, Cambridge, MA 02138)
D. O. Muhleman (California Institute of Technology, Pasadena, CA 91125)

Understanding of the important chemical and dynamical processes on Titan relies on accurate observational data of the abundances of molecular species. In our ongoing campaign to study Titan's atmosphere, we observed rotational lines of key species at millimeter wavelengths using the Owens Valley Radio Observatory Millimeter Array. An interferometer permits sideband isolation, allowing accurate line to continuum measurement of very broad spectral lines like those on Titan, a distinct advantage over observations made with single dish instruments.
In 1994 we observed the CO(1-0) line at 115.27 GHz, and in 1995 the HCN(1-0) and HC_3N(24-23) lines at 88.63 and 218.32 GHz, respectively. Carbon monoxide was found to be uniformly distributed at 50 ± 10 ppm from 60km to at least 200 km. We are insensitive to the CO abundance below 50 km, but our result is consistent with the original detection of CO in Titan's troposphere (Lutz *et al.* 1983). The HCN line is best fit with a profile starting at 50 ppb at an assumed HCN condensation altitude (near 90 km) and increasing to near 1 ppm at 300 km. In contrast to CO and HCN, HC_3N has a very narrow line, less than 1 MHz in width. This demands that HC_3N be limited to altitudes higher than $\sim$325 km (50μbar), best fit by a uniform 10 ppb profile above that point.

PPI/HASI (PRESSURE PROFILE INSTRUMENT) FOR THE HUYGENS SPACECRAFT

A.-M. Harri and G.W. Leppelmeier, T. Mäkinen, A. Lehto, R. Pirjola, T.Siili (Geophysical Research Division, Finnish Meteorological Institute)
B. Fagerström (Lab. of Aerodynamics, Helsinki Univ. of Technology)
T. Siikonen (Lab. of Applied Thermodynamics, Helsinki Univ. of Technology)

The HUYGENS entry probe will be sent into the Titan atmosphere by the CASSINI spacecraft. During the 3 hour descent the Huygens Atmospheric Structure Instrument (HASI) will observe a comprehensive set of variables, including pressure, temperature, density and atmospheric electricity. The Titan atmospheric pressure profile will be recorded by the Pressure Profile Instrument (PPI/HASI), provided by Finnish Meteorological Institute (FMI).
The principal sections of the PPI are the sensor boom, Kiel-probe with pitot tube, pressure sensors (Barocap) inside the Huygens body and pressure tube connecting the Kiel-probe and the pressure sensors.
PPI uses pressure sensors with three different sensitivities to cover the pressure range Titan atmosphere. The sensor technology is a heritage from a concept that has been used in earlier space and terrestrial applications.
The PPI starts measurements at an altitude of 160 km, producing 28 bits of data per second. Measurements are designed to continue beyond the time of impact on the surface of Titan, until Huygens stops operating.
Preliminary scientific analysis of the PPI/HASI mission has been performed. In addition simulations of the actual Titan environment and the response of PPI thereto have been carried out.

TITAN ATMOSPHERIC CIRCULATION

F. Hourdin and O. Talagrand (Laboratoire de Météorologie Dynamique du CNRS, Paris, hourdin@lmd.ens.fr)
D. Gautier, R. Courtin (DESPA, Obs. Paris-Meudon)
C. P. McKay, P. Rannou (NASA/Ames)

In agreement with the very indirect observations we have, the LMD general circulation model of Titan predicts strong prograde zonal winds near the 1-mbar level, of the order of 100 m/s (Hourdin et al., 1995 Icarus, 117:358-374). In the model this atmospheric "superrotation" is created by a combination of upward transport of angular momentum by the mean meridional Hadley-like circulation and equatorward transport in the stratosphere by large scale eddies, a mechanism first suggested for Venus by Gierash (1975, J. of Atmos. Sci., 32:1038-1044). The model shows that the waves responsible for the equatorward transport of angular momentum are created by dynamical unstabilities on the equatorward flank of the high latitudes jets. However, the model also predicts latitudinal temperature gradients much weaker than observed. This deficiency was attributed to a lack of latitudinal forcing in the model which does not take into account the latitudinal variations of chemical species and aerosols. In fact, it appears more and more clearly that coupling between atmospheric dynamics, chemistry and aerosol physics play a major role in the climate of Titan (e.g. Bézard et al., 1995, Icarus, 113:267-276, Hutzell et al., Icarus, 119:112-129). Prediction of this complex world and confrontation to remote and in-situ measurements at the time of the Cassini-Huygens mission is probably one of the most challenging subject for the coming years in that field.

TITAN'S ORIGIN AND EVOLUTION

Donald M. Hunten (Lunar and Planetary Laboratory, The University of Arizona, Tucson, AZ 85721, USA)

The mean density suggests that Titan condensed from a circum-Saturnian nebula, and the atmospheric composition suggests that ammonia and methane were included. Residual heat from the accretion could give a high enough vapor pressure of ammonia so that photolysis could convert it to N_2. After this heat was lost, the surface pressure may have been as low as 0.2 bar, with a negligible greenhouse effect leaving the temperature at 74 K. The increasing output of the Sun would gradually raise this temperature until a significant greenhouse effect could be supported, leading eventually to the present-day 94 K and 1.5 bars. One alternative accretion scenario that can be tested by Cassini is that nitrogen came in as N_2, along with Ne and Ar.

THE HUYGENS ACP EXPERIMENT FOR THE ANALYSIS OF TITAN'S AEROSOLS

G.M. Israël, M. Cabane (Service d'Aéronomie du CNRS, 91371 - Verrières le Buisson, France)
W. Riedler, (Space Research Institute, Graz 8010 Austria)
F. Raulin, (LISA, Univ. Paris VII et Paris XII, Creteil, 94010, France)
H. Niemann (NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA)

Two kinds of particles are present in Titan's atmosphere : (1) a photochemical aerosol formed at high altitude (≅ 350 km) through ionisation and dissociation of hydrocarbons and nitrogen by solar photons and charged particles of the Saturn magnetosphere, which slowly precipitates through the stratosphere and (2) particles of condensed hydrocarbon and nitriles in the lower stratosphere down to the surface .In the frame of the Cassini Mission, an experiment (Aerosol Collector Pyrolyser) will be flown aboard the Huygens probe, in order (1) to determine the chemical make-up of the photochemical aerosol and, (2) to measure the relative abundance of condensed organics. The ACP instrument will collect the aerosols and/or cloud particles during the descent of the probe, first in the region 130 to 35 km, and again in the region 22 to 17 km. For each region, after evaporation and pyrolysis in an oven of the collected matter (on a filter) the instrument will ensure the transfer of the gas products to the huygens GCMS instrument. The sampling system requires a pumping device which forces the flow of the Titan atmosphere through the collecting filter made of stainless steel fibres. A filter moving mechanism is actuated during the descent, first to move the filter in its sampling position, then to retract it back inside the oven. The other important element of ACP is the gas transfer sub-system which has been optimised for the chemical analysis by the GCMS, using both the direct mass spectrometer mode for each of the three selected temperatures of the filter and the gas chromatograph mode for the pyrolysis temperature at 600°C.

ATMOSPHERIC ENTRY OF LARGE METEOROIDS: COMPARING VENUS, EARTH, AND TITAN

B.A.Ivanov (Institute for Dynamic of Geospheres, RAS, Moscow)
G. Neukum (Institute for Planetary Exploration, DLR, Berlin, Germany)
A.T.Basilevsky and V.P.Kruchkov (Vernadsky Institute, RAS, Moscow)

The atmospheric breakup of large meteroroids is a natural process important for understanding of observed irregular impact craters and strewn fields on Earth and Venus. The preparation for the Cassini-Huygens mission gives an opportunity to revisite the problem of an atmospheric entry and breakup of meteoroids. We present the photo-geologic study of Venusian multiple craters, followed by a numerical modeling of the meteoroid's flight through the atmosphere in comparison with more simple models. The simulation take into account the brittle/ductile properties of the meteoroid material: the Grady-Kipp-Melosh model of tensile failure is accompanied with a simple model of the shear failure. The main difference to previously published models consists in the treating of the post-failure deformation of the damaged material as a flow of a cohesion-less media with a dry friction. Numerical results are used to make a parametrization of a simple Grigoryan-like model, which is applied to predict the atmospheric shielding effect on Titan. The model is tested by comparison with Venusian crater size-frequency distribution. The „turndown" crater diameter (when craters deficiency begins) for icy projectiles on Titan is estimated as 6 to 8 km for the modern atmosphere.

MODELING TITAN'S IONOSPHERE

C. N. Keller (Dept. of Physics, Univ. of Jos, Jos, Nigeria)
V. G. Anicich (NASA Jet Propulsion Laboratory, 4800 Oak Grove Dr., Pasadena, CA 91109 USA)
T. E. Cravens (Dept. of Physics & Astronomy, Univ. of Kansas, Lawrence, KS 66045 USA)

We have modified the Keller, Cravens, and Gan (1992) model of the ionosphere of Titan. The current model is a one-dimensional photochemical model, which takes into account newly measured gas phase kinetic rates, particularly those of the higher mass hydrocarbons and nitriles. The model neutral atmospheres developed by both Yung et al. (1984, 1987) and Toublanc et al. (1995) were used in this model. The current model includes more neutral and ion species, and discriminates among the various higher mass hydrocarbon and nitrile ion species. Ion-neutral chemistry produces H_2CN^+ as the single major ion species at the ionospheric peak (an altitude of 1055 km); however, the total density of all the higher mass hydrocarbons is more than that of H_2CN^+. The higher mass hydrocarbons include such species as: c-$C_3H_3^+$, $C_5H_5^+$, and $C_3H_5^+$. Another important ion species is $H_2C_3N^+$. Based on this model we expect the higher mass channels (e.g., 39, 41, 52, and 65 amu) of the Cassini Ion-Neutral Mass Spectrometer to be more active than previous models have predicted.

MHD-SIMULATIONS OF THE INTERACTION BETWEEN TITAN AND THE MAGNETOSPHERE OF SATURN

A. Kopp and W.-H. Ip (Max-Planck-Institut für Aeronomie, Katlenburg-Lindau, D-37191 Germany)
G.T. Birk (Ludwig-Maximilians-Universität, München, D-81679 Germany)

We investigate the electrodynamical interaction of Titan with the magnetosphere of Saturn by means of 3D resistive MHD simulations in a cylindrical coordinate system, which allows to model either the whole magnetosphere of Saturn around Titan's orbit or to perform local simulations of Titan's direct environment. The latter one is of particular interest for the INMS (Ion and Neutral Mass Spectrometer) of the Cassini mission. For this purpose we use a two-fluid approach and solve self-consistenly the MHD equations for the plasma as well as the fluid equations for the neutral gas emanating from Titan's atmosphere. Our equations consider ionisation/recombination and elastic collisions (i.e. friction) between the two species. Quite similar to the Io/Jupiter system we expect mass loading effects to modify the structure of the magnetosphere near Titan in a significant way, so that particle and magnetic field measurements should allow to draw conclusions for the atmospheric structure of Titan. We present first results of this project.

STRATOSPHERIC CIRCULATION ON TITAN: A DIRECT MEASUREMENT

Theodor Kostiuk, Kelly Fast, T.A. Livengood, Fred Espenak and David Buhl (NASA/Goddard Space Flight Center, Greenbelt, MD 20771)
Jeffrey Goldstein, Tilak Hewagama, Kyung Ho Ro (Challenger Center, 1029 North Royal Street, Suite 300 Alexandria, VA 22314)

Ethane emission lines from Titan's stratosphere were measured with a spectral resolving power of $\sim 10^7$ using the Goddard Infrared Heterodyne Spectrometer at the NASA Infrared Telescope Facility on Mauna Kea, Hawaii in October 1995. The line center frequencies of the resolved lineshapes from the east and west hemispheres of Titan were determined. A comparison of the retrieved frequencies provides a measure of the direction and a mean magnitude for the speed of the circulation in the $2 - 0.1$ mbar pressure altitude regions. The relative Doppler shift of the lines from the two hemispheres yield a prograde wind direction and a limb-to-limb magnitude of $\sim$ 140 m/sec ($\sim$ 70 m/sec horizontal). The instrumental stability permits absolute measurements to $\leq$ 10 m/s, while the signal-to-noise on the data limits the limb-to-limb uncertainty to $\sim$ 100 m/sec. Recent improved analyses and interpretation will be discussed and new results from the analysis of measurements taken in September 1996 will be presented.

THE RADIO AND PLASMA WAVE INVESTIGATION FOR CASSINI

W.S. Kurth, D.A.Gurnett, and D.L. Kirchner (Dept. of Physics & Astronomy, The University of Iowa, Iowa City, IA, 52242 USA)
R. Manning (Observatoire de Paris, Meudon, France)
A. Meyer (CETP/UVSQ, Velizy, France)
L. Aahlen (Swedish Inst. of Space Physics, Uppsala, Sweden)
L. Woolliscroft (University of Sheffield, Sheffield, United Kingdom)

The Radio and Plasma Wave Investigation (RPWS) for the Cassini Orbiter is a comprehensive system designed to measure wave phenomena in the Saturnian system from 1 Hz to 16 MHz. The instrument utilizes 3 monopole antennas 10 m in length for measurements across this entire bandwidth, a triaxial search coil magnetometer for waves in the range from 1 Hz to 12.6 kHz, and a spherical Langmuir probe for measurements of thermal plasma, especially near Titan. The electronics includes a set of receivers which enable the measurement of all four Stokes parameters and the direction of arrival of planetary radio emissions and Saturn electrostatic discharges; the spectrum, mode, and wave vector of plasma waves; the waveform of radio and plasma waves; and small-scale density structures through the use of two of the monopole antennas in a Langmuir probe mode. The instrument will make accurate measurements of local electron densities and temperatures using a sounder, the Langmuir probe, and through the detection of plasma resonances and cutoffs.

TITAN'S PHOTOCHEMISTRY: NEW RESULTS

Luisa-María Lara (IAA-CSIC, Apdo. 3004, 18080 Granada, Spain)
Enmanuel Lellouch (DESPA, Observatoire de Paris-Meudon, F-92195, France)

A new photochemical model for Titan's neutral atmosphere has been recently developed (Lara et al., JGR, 101, E10, 23261-23283, 1996). Its most important results are the following: (i) fitting the methane thermospheric profile and the stratospheric abundance of the major hydrocarbons requires a methane stratospheric mixing ratio of 1.5-2% rather than 3%, (ii) the observed CO_2 profile can be modeled by assuming a plausible external source of water of $\sim 6 \times 10^6$ cm^{-2} s^{-1}, and CO is close photochemical equilibrium (production equal loss within $\sim$ 15%), (iii) with the adopted chemistry, it does not seem possible to simultaneously fit hydrocarbons and nitriles. In particular, the HCN stratospheric profile requires an eddy diffusion coefficient at 100-300 km 5-20 times larger than that necessary for hydrocarbons. McKay (PSS, 44, 741-747, 1996) has recently estimated that the production of Titan's haze represents a loss rate of N atoms of about 10^8 cm^{-2} s^{-1}. This is comparable to the net HCN production rate. Therefore, if the haze is produced through HCN polymerization, then the haze formation represents a major sink for HCN. We investigate this possibility by introducing an additional loss term for HCN in the model. We will also present preliminary attempts to model the observed latitudinal variations of the minor species.

The Magnetospheric Imaging Instrument (MIMI) for the NASA Cassini Mission to Saturn and Titan-Titan Science Objectives

S. M. Krimigis, A. F. Cheng, E. P. Keath, B. H. Mauk, D. G. Mitchell, R. W. McEntire, E. C. Roelof, and D. J. Williams, all at the Applied Physics Laboratory of The Johns Hopkins University; W.-H. Ip, E. Kirsch, S. Livi, B. Wilken, all at Max Planck Institute for Aeronomie; G. Gloeckler and D. C. Hamilton both at the University of Maryland; T. P. Armstrong, University of Kansas K. C. Hsieh, University of Arizona; L. J. Lanzerotti, Lucent Technologies J. Dandouras, D. Alcayde, H. Reme, and J. A. Sauvaud, CESR, Toulouse

The Magnetospheric Imaging Instrument (MIMI) will provide global images of Saturnian hot plasmas remotely, and will make comprehensive in-situ hot plasma measurement, including charge state and elemental composition. MIMI consists of an Ion and Neutral Camera (INCA) for magnetospheric imaging in energetic neutral atom flux between 10 keV and ~ 8MeV, a Charge-Energy-Mass-Spectrometer (CHEMS) for composition and charge state measurements of ions from 10 to 230 keV, and the Low Energy Magnetospheric Measurements System (LEMMS) for measurements of energetic ions with Z >= 1 in the range 0.02 <= E <= 10.5 MeV and electrons 0.015 <= E <= 1.5 MeV. In this presentation, we discuss the science focus of the MIMI investigation during Titan encounters. Topics include sensing of the Titan exosphere to altitudes unmeasureable by other direct methods; composition and energy of pickup ions created by UV and impact ionization of Titan atmospheric constituents; Titan atmospheric absorption of magnetospheric energetic ions and electrons; and modification of energetic charged particle trajectories by intrinsic or induced Titan magnetic fields.

Sputtering induced heating of Titan's upper atmosphere

H. Lammer*, W. Stumptner*,+, S.J. Bauer*,+ (Space Research Institute, *Austrian Academy of Sciences, Graz, and +Institute for Meteorology and Geophysics University of Graz, Austria)

Energetic processes like Titan's plasma interaction with Saturn's magnetosphere act to change the character of the upper atmosphere. It is shown that the bulk of the energy of energetic nitrogen ions is deposited below the exobase, in a region where no Voyager temperature measurements exist. This study takes into account, energy fluxes, heat conduction, thermal conductivity and thermal transport processes. The energy deposition is responsible for heating effects and changes in the scale height and number density in the upper haze region, which could be important for the Huygens entry probe.

AN OVERVIEW OF THE HUYGENS PROBE MISSION TO TITAN

Jean-Pierre Lebreton, ESA's Space Science Department, ESTEC, Noordwijk, The Netherlands

The Huygens Probe is designed to explore the atmosphere of Saturn's moon Titan. It will be delivered to Titan by the Cassini Saturn Orbiter at the end of the first Orbit around Saturn. The separation from the Orbiter will take place 3 weeks before entry. It will enter into the atmosphere at a velocity of about 6 km/s. After entry, the main parachute will be deployed at about mach 1.5, i.e. at 400 m/s, and the the heat shield will be ejected 30 s later. About 15 minutes in the descent, the main parachute is replaced by a smaller stabiliser chute for the rest of the descent through the atmosphere of Titan down to the surface which will last between 2 and 2 1/2 hours. The scientific objectives are to measure the chemical composition and the physical properties of the atmosphere and to determine the physical state and the composition of the surface at the landing site. The Huygens payload is made of six instruments which will have direct access to the atmosphere after the parachute deployment. One of the instrument will perform accelerometer measurements during the 3-minute entry phase. The probe will hit the surface of Titan at a low 6 m/s. During the descent through the atmosphere and possibly for a few minutes on the surface if it survives the landing, Huygens will transmit its data to the overflying Orbiter, for onboard recording and subsequent transmission to Earth after the Titan flyby. The transmission with the Orbiter will last 3 hours, which includes a provision for at least 1/2 hour of data transmission on the surface. Following a launch in October 1997, The Huygens Probe entry in Titan's atmosphere is planned in late November 2004. This paper presents an overview of the Probe mission and a brief description of the payload.

MHD MODELS OF PLASMA FLOW AROUND TITAN

S. A. Ledvina (Dept. of Physics & Astronomy, University of Kansas, Lawrence, KS 66045, USA)
T. E. Cravens (Dept. of Physics & Astronomy, University of Kansas, Lawrence, KS 66045, USA)
C. J. Lindgren (Koch Industries, Wichita, KS 67201, USA)

Titan's plasma environment is studied using a two-dimensional, quasi-multifluid and a three-dimensional single-fluid, magnetohydrodynamic model. The two-dimensional model included generic light, medium, and heavy species. Titan first begins to affect the external magnetospheric plasma flow at a distance of about 10 Titan radii. The plasma flow is subsonic, although super Alfvénic, and a bow shock does not appear in the results of either model. The flow inside 2 R_t is much slower due to the build-up of a magnetic barrier and due to the collisional interaction of the plasma with Titan's neutral atmosphere. The three-dimensional MHD model is used to study the wake region in which the magnetic field lines are strongly draped. Comparisons are made between the modeled plasma flow speed, pressure, density and magnetic field strength, and measurements made in the wake by Voyager 1.

TITAN'S SURFACE FROM GROUND-BASED SPECTROSCOPY

Emmanuel Lellouch (DESPA, Observatoire de Meudon, F-92195 Meudon, France)

Titan's haze optical depth is sufficiently low at near infrared wavelengths that the surface may be detected in windows of weak methane gas opacity. Numerous observations in such windows (at 0.94, 1.07, 1.28, 1.6 and 2 micron) have shown that Titan's geometric albedo varies with orbital position, defining repeatable lightcurves whose amplitudes increase with increasing wavelength. These lightcurves show a maximum brightness near greatest ~~eastern~~ elongation at all wavelengths, indicating that Titan's surface is heterogeneous. Two more spectral regions where the surface can likely be sensed have been recently discovered, at 2.9-3.0 and 4.9 micron. The absolute geometric albedos observed by different teams show considerable disagreement, resulting in very uncertain albedos for Titan's surface. Nevertheless, several studies independently find that Titan's surface is bright in the infrared, and that its spectrum is not flat with wavelength and generally consistent with the presence of water ice. The existence of longitudinal variations proves the existence of another surface component but its nature (and even its relative brightness compared to water ice) is unknown. Silicates, moderately extended hydrocarbon lakes, and tholins remain reasonable possibilities that are not inconsistent with the near-infrared spectra (but not particularly supported either); notably the presence of the latter two on Titan's surface is expected from photochemical considerations. Future investigations of Titan's lightcurve at the longest wavelengths could provide new constraints on Titan surface models.

INSIDE TITAN'S HAZE: CURRENT MODELS AND THE VIEW FROM HUYGENS

M.T. Lemmon, M.G. Tomasko (Lunar and Planetary Laboratory, Univ. Arizona, Tucson, AZ 85721-0092 USA)

The design of the Descent Imager/Spectral Radiometer (DISR) for the Huygens probe required the development of models of the radiation field inside Titan's atmosphere. To ensure the best performance, the models incorporated cloud physics and were tested against several observational constraints via a radiative transfer model. The aerosols are modeled as cluster-cluster aggregates, and model predictions are generated for polarization (external observations only) and intensity as a function of position and direction of observation. We will report on recent additions to the model, including 1) a realistic surface phase function; 2) a parameterization of the scattering properties of aggregate aerosols; and 3) a separation between northern and southern regimes, allowing for a more realistic haze model at the (northern hemisphere) location of the Huygens landing site. These features allow the model to make more useful predictions about the spectral and spatial variations that will be observed by DISR as well as the observability of different surface contrasts during the descent and from outside Titan's atmosphere.

THE FACE OF TITAN: EXPANDED, MULTI-COLOR ALBEDO MAPS FROM HST IMAGES

M.T. Lemmon, P.H. Smith (Lunar and Planetary Laboratory, Univ. Arizona, Tucson, AZ 85721-0092 USA)
J.J. Caldwell, Dept. of Physics and Astronomy, York Univ., North York, Ontario, Canada

New albedo maps of Titan's surface have been derived from 1994 and 1995 HST WFPC2 images with the F673N, F850LP, and 1042M filters during 19 HST visits. The 1995 images show the large, bright feature seen in maps made from the 1994 images (Smith et al. 1996, Icarus 119, 336-349), but also show orbital phases not seen in 1994. The new maps show a bright feature near 20 W, 45 N (a region not observed in 1994) and another near 40 E, 30 N. A bright feature was observed at the latter location in 1992 at several wavelengths (with WFPC), but this feature was not seen in 1994. The contrasts of both of the new features have a color dependence different from the large, leading-hemisphere bright region, having a blue slope rather than a red slope. The blue slope is also observed in the region near 180 W, 15 N in both 1994 and 1995. The features on the map are used to generate model images and synthetic light curves for comparison with existing near-infrared observations. The model images are also used to explore and correct the systematic effects of several mechanisms for removal of Titan's haze from the images. Atmospheric models constrained by Titan's albedo, north-south asymmetry, and limb darkening will be used to determine the visibility of the surface and clouds as a function of wavelength and the true surface reflectivity and to constrain the properties and altitudes of possible clouds.

MULTI-INSTRUMENT STUDIES OF TITAN'S SURFACE FROM CASSINI

R. D. Lorenz[1], C. C. Porco[1], S. D. Wall[2], R. L. Kirk[3], J. I. Lunine[1], L. A. Soderblom[3] and R. H. Brown[1] ([1] LPL, U. Arizona [2] JPL [3] USGS, Flagstaff)

The Cassini orbiter carries high-resolution remote sensing instruments with which to characterize the surface of Titan. These are the RADAR, the Imaging Science Subsystem (ISS) and the Visual & Infrared Mapping Spectrometer (VIMS). The synergy of active and passive microwave measurements with multispectral and high-resolution imaging is unique to Cassini and will be vital in understanding Titan.
This synergy arises from the different capabilities and expected contributions of each instrument. RADAR can achieve spatial resolutions as high as $\sim 400m$. At this resolution, ISS coverage will be $\sim$ 10 times greater than that of RADAR, providing the broad areal context in which to place the RADAR results. Boresighted with ISS, VIMS will contribute near-simultaneous spectroscopic imaging data, crucial for delineating the compositional environment of the regions covered by ISS and RADAR. All instruments will likely contribute topographic information.
We will examine the contributions expected from these instruments, separately and together, and outline the distribution and resolution of Titan surface coverage. Without a scan platform, the optical instruments and the RADAR cannot be pointed at Titan simultaneously; orbiter time must be shared between them during the $\sim$ 40 Titan flybys to be made by Cassini. We will explore strategies for maximizing the science return given this limitation.

CLIMATE EVOLUTION ON TITAN

R. D. Lorenz, and J. I. Lunine (Lunar and Planetary Lab, University of Arizona, Tucson, AZ 85721, USA)
C. P. McKay (NASA Ames Research Center, Moffett Field, CA 94035, USA)

Titan's present climate benefits from a substantial greenhouse effect due to methane, nitrogen and hydrogen, although photochemical haze blocks a large fraction of the incident sunlight. We have determined (Science, submitted 1996) that loss of the methane greenhouse due to episodic delivery of methane failing to match depletion by photolysis could have led to atmosphere collapse in the past, especially with a faint early sun. We review this finding and examine the favoured epoch for it to occur: before the sun reached its present luminosity, but after geothermal heat flow due to accretional heating had fallen. Additionally, we examine Titan's fate as the sun increases luminosity and becomes a red giant - will Titan become a balmy paradise, or do photochemical and radiative feedbacks conspire to keep it in deep freeze ?

THE NATURE OF TITAN'S SURFACE

J.I. Lunine and R.D.Lorenz (LPL, The University of Arizona, Tucson AZ, 85721 USA)

In the turn-of-the-century American fairy tale *The Wizard of Oz*, an encounter takes place between a mysterious Wizard and four seekers of fortune. Brought in to the Wizard one by one, each sees a very different apparation, not one of which, in the end, resembles the true Wizard. In many ways this story is an allegory for the nature of Titan's surface, which presents diverse faces to various remote sensing techniques and theoretical constraints. The photochemical destruction of the entire atmospheric inventory of methane on timescales 1% the age of the solar system seems to demand a deep surface hydrocarbon reservoir as source and sink of the photochemistry. Radar observations seem to rule out such a global hydrocarbon ocean, though the reflectivities and their polarizations remain difficult to interpret and are like no other surface examined by radar. Remote sensing through near-infrared windows between methane bands suggest the presence of water or other ices, but these cannot dominate based on the radar signature. Hubble Space Telescope and ground-based adaptive optics images through the near-infrared windows reveal complex but subtle variations in surface brightness. Although remote sensing data will improve in quality through the next decade, only the Cassini/Huygens mission is likely capable of pulling back the curtain to reveal the true nature of the surface of this mysterious giant moon.

PPI RESULTS FROM THE BALLOON DROP EXPERIMENT OF THE HASI PRESSURE PROFILE INSTRUMENT

Teemu Mäkinen, Asko Lehto, Pekka Salminen, Gilbert Leppelmeier, Ari-Matti Harri, Finnish Meteorological Institute, Geophysical Research, P.O.Box 503, FIN-00101 Helsinki, Finland

At December 1995 a balloon drop experiment was conducted at León, Spain, for the HASI (Huygens Atmospheric Structure Instrument) instrument of the Huygens probe. A part of HASI is the Pressure Profile Instrument (PPI) which will measure the atmospheric pressure profile of Titan during the descent at November 2004. The experiment platform was carried by a balloon to an altitude of 30 kilometers and it made a subsequent parachute–assisted descent. The instruments functioned basically as expected. The vertical flight trajectory and pressure profile was reconstructed by using the collected data of the pressure instrument and the simultaneous temperature measurements. Some turbulent phenomena were detected. The experiment demonstrated the nominal performance of the PPI instrument and serves as a real-like test flight for the actual mission.

PHYSICAL PROPERTIES OF CONDENSED ETHANE IN TITAN'S NORTH POLAR HOOD REGION

L.A. Mayo (Hughes STX Corporation, Greenbelt, Maryland, USA)
R.E. Samuelson (NASA Goddard Space Flight Center, Greenbelt, Maryland, USA)

Originally, with the aid of Voyager 1 IRIS spectra, and considering only absorption and emission, Samuelson and Mayo (1991, Icarus 91, 207 - 219) determined the vertical distribution of aerosol opacity in the thermal infrared associated with Titan's north polar hood. In addition to a uniformly distributed aerosol haze between 40 and 300 km, they inferred a second component in the lower stratosphere where hydrocarbon condensation is expected. Shortly thereafter, Samuelson (1992, BAAS 24, 947 - 948) considered the role of scattering and inferred that the wavenumber dependence of opacity for the second component matched that of a thin hydrocarbon cloud composed of moderately large particles. Since then it has been discovered that methane apparently is highly supersaturated in Titan's upper troposphere, and interest has been renewed in condensation and precipitation processes under such conditions. In this study, the role of condensed stratospheric ethane as potential nucleation centers for tropospheric methane is considered. The IRIS north polar hood limb tangent data is reanalyzed to include collisionally induced absorption and ethane particle scattering yielding a stratospheric ethane particle radius of about 10 microns. Abundances for the ethane condensate cloud are also inferred. The impact of these results on seasonal variations are examined.

SCIENTIFIC OBJECTIVES OF THE HASI/PPI INSTRUMENT

Teemu Mäkinen, Ari-Matti Harri, Finnish Meteorological Institute, Geophysical Research, P.O.Box 503, FIN-00101 Helsinki, Finland

As a part of the Cassini mission to Saturn, the Huygens probe will descend to the surface of the largest satellite Titan, the only moon in the solar system having a substantial atmosphere. Onboard the Huygens probe is the Pressure Profile Instrument (PPI), which measures the total atmospheric pressure during the descent. The extreme conditions in the atmosphere require special attention when processing the results. The measuring strategy is based on a compromise between resolution and reliability. The general scientific return of the instrument is discussed. The characteristics of the atmospheric environment encountered by the PPI during the active operation phase is estimated. The PPI instrument's capability to fullfill the main scientific objectives as a part of the Huygens Atmospheric Structure Instrument (HASI) is investigated.

THE CASSINI/HUYGENS MISSION TO THE SATURNIAN SYSTEM

D. L. Matson and D. L. Matson (Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91106)

The Cassini mission is designed to carry out an in-depth exploration of the Saturnian system. The spacecraft will start its interplanetary journey with an October 1996 Titan-4 Centaur launch. Upon arrival at Saturn, Cassini will go into orbit about the planet. The orbiter will deliver the Huygens probe to Titan in November, 2004. After deceleration in the upper atmosphere, Huygens will deploy a parachute system and its six instruments will make scientific measurements and observations as it descends to the surface. These data then will be transmitted to the orbiter which, in turn, will relay them to the Earth. The orbiter will then commence a four year long tour of the Saturnian system. With its complement of 12 instruments, Cassini is capable of making a wide range of in situ and remote sensing observations. There will be repeated close flybys of Titan both to make measurements and obtain observations and for gravity-assisted orbit changes which will enable Cassini to visit other satellites, various parts of the magnetosphere, and obtain occultations of the rings and atmospheres of Saturn and Titan. During the span of the mission, Cassini will also record temporal changes in many of the properties that it can observe. The Cassini mission is a joint undertaking by NASA and ESA. This work was carried out at Jet Propulsion Laboratory, California Institute of Technology, under contract to NASA.

THE PROPERITES AND EFFECTS OF TITAN'S ORGANIC HAZE

C.P. McKay (NASA Ames Research Center, Moffett Field, CA 94035, U.S.A.)

Titan's organic haze is the the dominant absorber of solar energy in Titan's atmosphere, creating an anti-greenhouse effect. Its variation over time may have had important implications for Titan's surface temperature. The haze is potentially an important sink of photochemically produced carbon and nitrogen compounds. Laboratory simulations and microphysical models suggest that the haze is a sink for C of 4×10^8 cm^{-2} s^{-1}, and a sink for N of 1×10^8 cm^{-2} s^{-1}. The C sink is small compared to condensation of hydrocarbons but the sink for N is comparable to the total production rate of HCN. Because estimates of the eddy diffusion profile on Titan have been based on the HCN profile, inclusion of this additional sink for N will affect estimates for all transport processes in Titan's atmosphere.

IDENTIFICATION OF TITAN SURFACE CHARACTERISTICS BY RADAR IMAGING: A SIMULATION

P.T. Melacci(2), R. Orosei(1), G. Picardi(1) and R. Seu(1)
(1) Info-Com Dept., University of Rome "La Sapienza", Via Eudossiana 18, I-00185 Rome, Italy
(2) Physics Dept., University of Perugia, Via G. Pascoli, I-06143 Perugia, Italy

We make use of a simulator of the active modes of the multimode Cassini radar to test the effects on the radar measurements of different hypotheses about the structure and composition of the surface of Titan. The simulator allows us to obtain a faithful evaluation of the performance of the instrument by considering the burst and single pulse duration, the pulse bandwidth, the pulse repetition frequency and all other parameters which can be optimized according to the operative mode. The topography of Titan, although practically unknown, has been simulated by use of high definition maps of portions of the surface of other Solar System bodies. We have modelled the backscattering coefficient of the surface of Titan as a function of its composition and small-scale structure, by combining the available observational evidence with the latest electromagnetic modelling of surface backscattering by an inhomogeneous rough surface. Through many runs of the simulation program, we have tried to determine to what extent the measurements of the Cassini radar can be used to put constraints on the hypotheses about the nature of the surface of Titan.

A 1-D MHD MODEL OF TITAN'S IONOSPHERE UNDER INFLUENCE OF SATURN'S MAGNETOSPHERIC PLASMA

D. Mücke–Herzberg and F.M. Neubauer (Institute for Geophysics and Meteorology, Cologne, Germany)

Titan is an unique study case for plasma interaction as during its orbit around Saturn Titan may be located in the magnetosphere of Saturn or in the solar wind. In order to achieve understanding of this interaction a simulation project has been started. The model consists for the time being of an 1-D MHD code solving the continuity, momentum and induction equation for a given temperature curve. We account for the complex photochemistry of Titan's ionosphere by considering several ion species. A status report of the first stages of the project is given and first results are discussed.

EARTHBASED RADAR OBSERVATIONS OF TITAN

D. O. Muhleman (California Institute of Technology)
A. W. Grossman (UC Berkeley), B. Butler (NRAO), and M. A. Slade (JPL)

All of the Earthbased radar observations will be reviewed and the preliminary results of new radar observations involving the polarization effects on the reflections will be presented. The primary results are that the mean surface reflectivity at centimeter wavelengths is about 12 percent, with maximum reflectivity greater than 15 percent on the leading hemisphere of the satellite. Strong evidence that the leading hemisphere may be covered with relatively clean ice relative to the dark hemisphere will be presented. A highly speculative interpretation of these results is that the structures on the leading hemisphere are at a high enough altitude to cause them to be relatively free from hydrocarbon deposits, perhaps due to cleansing from atmospheric precipitation. The darker surface structures at lower altitudes may contain poorly reflecting liquid hydrocarbons or tars. Alternatively, the lower reflectivity terrain may be dominated by silicates which would have a reflectivity of order 10 percent, low for Titan. Titan is more radar reflective than the surfaces of all the terrestrial planets but less than the icy Galilean satellites.
The most definitive radar test for surface ice are polarization ratio measurements. We have attempted these with the VLA/Goldstone Radar configuration and the data are being processed at the time of this writing. The measurement is very difficult because the instrument only provides a unity signal-to-noise ratio in a one hour integration. Radar results will be compared to our thermal emission measurements at similar wavelengths.

THE IONOSPHERE OF TITAN AND ITS INTERACTION WITH SATURN'S PLASMA ENVIRONMENT

A.F. Nagy (The University of Michigan, Ann Arbor, USA)

This paper will summarize the latest model calculations of Titan's ionosphere. The presentation will focus on the predicted ionospheric composition, dynamics and energetics. The various possible ionospheric conditions and the interaction of the ionosphere with Saturn's magnetosphere and magnetosheath will also be discussed.

THE INFRARED SPECTRUM OF TITAN AND SCIENCE WITH CIRS

C. A. Nixon and F. W. Taylor, S. B. Calcutt, C. L. Hepplewhite (Atmospheric, Oceanic and Planetary Physics, University of Oxford)

A general purpose radiative transfer code for planetary atmospheres has been adapted and applied to Titan. We use it to calculate synthetic spectra for Titan's atmosphere in the infrared, including molecular line absorption, molecular continuum opacity and the scattering effects of atmospheric particles. A number of atmospheric models are investigated; those in which the size and altitude distribution of the stratospheric haze is varied; and models of the troposphere both with and without condensed methane clouds, and also with supersaturated methane. We compare the model spectra to experimental data from both ground based and spacecraft observations, and reassess the mixing ratio of CO in the atmosphere. We also calculate predicted spectra for CIRS (the Composite Infrared Spectrometer on Cassini) using measured instrument parameters, and re-assess current science objectives in light of the expected instrumental performance.

A NEW WINDOW ON THE TREASURES OF TITAN

T. Owen (U of Hawaii, Inst for Astron, 2680 Woodlawn Drive, Honolulu, HI 96822); C. Griffith (U of Northern Arizona, Flagstaff, Arizona); T. Geballe (Joint Astron Centre, Hilo, Hawaii); B. Han (U of Hawaii, Honolulu, Hawaii); D. P. Cruikshank (Ames, Moffett Field, CA) ; C. McKay (Ames, Moffett Field, CA)

The atmosphere of Titan appears to be transparent down to the satellite's surface at wavelengths around 2.85 μm. The longwave side of this window is closed by absorption of ethane and methane on Titan, shorter wavelengths are blocked by telluric H_2O and CO_2. Titan is brighter at 2.9 μm than water ice or any tholin proposed to date would permit. A dusting of CO_2 deposited from the atmosphere — from the reaction of CO + OH — is capable of supplying the observed reflectivity. Observations presently scheduled for ISO will test this interpretation in the region from 2.45 — 2.85 μm.

TITAN IN THE SOLAR SYSTEM

T. Owen (University of Hawaii, Institute for Astronomy, 2680 Woodlawn Drive, Honolulu, HI 96822)

With a nitrogen dominated reducing atmosphere that is denser than our own, Titan is a very special place. As we try to understand the origin and evolution of this atmosphere, we are naturally led to comparisons with other solar system objects. The composition of Titan's atmosphere is similar to those of Pluto and Triton, whereas Ganymede and Callisto, with masses similar to Titan's, have no atmospheres. Why? Mars, which is more massive than Titan, has a much thinner atmosphere, apparently because of impact erosion. Why? On Earth, we can see the result of massive deposition of CO_2 in the form of carbonate rocks. On Titan, there are sinks for both CO_2 and CH_4 as a result of atmospheric photochemistry. We can look for evidence of these depositional processes as we explore Titan's surface. The value of D/H on Titan compared with comets and other atmospheres provides another important clue.

CASSINI IMAGING STUDIES OF TITAN

C. C. Porco (Dept. of Planetary Sciences/LPL, University of Arizona, Tucson, AZ 85721, USA)

In their flybys of Titan in the early 1980's, the Voyager spacecraft relayed to Earth many important results concerning this fascinating satellite, but detailed images of its surface were not among them. The scattering and absorbing properties of its atmosphere and the spectral characteristics of the Voyager Imaging System were so precisely mismatched that only Titan's upper atmospheric features (hemispheric albedo asymmetry, detached haze layers, etc.) were captured in Voyager imaging data.

The Imaging Science Subsystem (ISS), the highest spatial resolution imager carried on the Cassini orbiter, has been specially outfitted to attempt imaging of Titan's surface and lower atmosphere. Moreover, Cassini's orbital tour through the Saturn system, during which Titan is encountered many times, will allow repeated opportunities for imaging studies. As a consequence, there is realistic hope of seeing with the ISS details of the lower regions of Titan's atmosphere and surface – down to a scale of < 50-m – with areal coverage greater than that obtainable by any other Cassini instrument at equivalent resolution.

In this presentation, I will describe Cassini Imaging Team plans for Titan atmospheric and surface observations, our science objectives, and the challenges and results we expect to encounter in interpreting Cassini Titan images.

INFRARED SPECTROSCOPY OF ORGANIC SURFACES

E. Quirico and **E. Quirico** (Laboratoire de Géophysique et Planétologie, 44072 Nantes, France)
B. Schmitt (LGGE-CNRS, F-38402 Saint Martin d'Hères, France)
S. Douté (LGGE-CNRS, F-38402 Saint Martin d'Hères, France)

The surface of Titan is expected to be covered by complex organic materials, whose characterization is particularly difficult and will be one of the aims of the DISR spectrometer of the CASSINI-HUYGENS mission. The physical and chemical states of these materials are rather unknown and, obviously, their optical properties too. In addition, the DISR instrument will record reflectance spectra, which are known to be significantly differents than laboratory transmission spectra due to the radiative transfer inside the surface layers. We are interested here to evaluate the potential information which could be derived from infrared spectroscopy of organic surfaces. We first present laboratory measurements of the optical properties of simple organic molecules (CH_4, C_2H_4, C_3H_8, etc.) in the near-infrared range, and discuss the various spectral effects induced by different physical state (mixture, dilution, temperature, etc.). Then, we present synthetic reflectance spectra of organic surfaces simulated from laboratory absorption coefficients and a bidirectionnal reflectance modeling. These results are finally applied to study the potential information one could hope to derive from the DISR measurements of the surface of Titan. These results are obviously also of interest for the study of cometary organics by the VIRTIS spectrometer aboard the orbiter of the ROSETTA mission.

INTERPRETATION OF SCATTERED LIGHT MEASUREMENTS AT TITAN'S LIMB

P. Rannou (NASA Ames Research Center, 245-3, Moffett Field, CA 94035, U.S.A)
M. Cabane (Service d'Aéronomie, B102, Univ. Paris 6, 4, place Jussieu, 75252 Paris cedex 05, France)
R. Botet (Laboratoire de Physique des Solides, Batiment 510, Université Paris-Sud, 91405 Orsay, France)
E. Chassefière (Laboratoire de Météorologie Dynamique, Univ. Paris 6, 4, Place Jussieu, 75252 Paris Cedex 05, France)

Images of the bright and dark limbs of Titan taken by Voyager 2 provided radial intensity profiles. Assuming some aerosols characteristics, these data permitted very early to retrieve useful information about the vertical and latitudinal distributions of spherical aerosols. Here, we use a microphysical model dealing with aggregated particles of fractal dimension D. This kind of aerosols was shown to be the most consistent to reproduce albedo data. With an accurate code of scattering by fractal aggregates, and aerosols distributions, we compare our model with the limb data. Using scans for several latitudes on Titan, and for 2 phase angles, we derive strong constraints on the aerosol structure, and on latitudinal variation of the aerosols distribution.

We mainly show that the aggregates are built with spheres of about 0.07 μm and must have a fractal dimension close to 2. The aerosol quantity is to vary by a factor 2 with latitude from 15 deg S to 55 deg N.

THE FIRST RESULTS FROM A COUPLE DYNAMICS-MICROPHYSICS MODEL OF TITAN'S HAZE

P. Rannou and C.P. McKay (NASA Ames Research Center, 245-3, Moffett Field, CA 94035, U.S.A)
F. Hourdin (Laboratoire de Météorologie Dynamique, Ecole Normale Superieure, 24, rue Lhomond, 75231 Paris Cedex 05, France)
M.Cabane (Service d'Aéronomie, B102, Univ. Paris 6, 4, place Jussieu, 75252 Paris cedex 05, France)

Recent work has shown that the aerosol distribution on Titan exhibits latitudinal features that cannot be explained by microphysical studies only. The latitudinal distribution of aerosols is recognized to be due to the winds. In addition, models of Titan's circulation have not been able to fully explain features such as the amplitude of seasonal variation of the temperature. In these models the aerosol component is fixed. It is known that the circulation should modify the aerosol distribution. In return, the aerosol haze contributes to the heating of the atmosphere, and may modify the wind pattern. These coupled effects of the circulation and of the microphysics may help to solve the difficulties encountered in each separate study. Using a GCM and a microphysical model of Titan aerosols, we performed a model able to take into account these interactions. We present here our coupled model and the first results that we obtain.

TIDES IN TITAN

N.J. Rappaport (Jet Propulsion Laboratory, 301–150, 4800 Oak Grove Drive, Pasadena, CA 91011, U.S.A.)
B. Bertotti (Dipartimento di Fisica Nucleare e Teorica, Universita di Pavia, Via Bassi, 6, I-27100, Pavia, Italy)

Tides raised in Titan by Saturn give rise to a static and a periodic deformation; both will be measured with Doppler tracking during the CASSINI Tour of the Saturnian System. The latter deformation is due to the significant eccentricity of Titan's orbit and has a frequency equal to the orbital angular velocity of Titan. This periodic perturbation must bring out an elastic response from the satellite. The ratio of the induced potential at the surface to the perturbing potential is the elastic Love number of degree 2, k_2. The elastic Love number depends critically on the shear modulus or rigidity μ of Titan. The bulk rigidity of Titan is highly uncertain. For a rocky body, $\mu = 5$ to 7×10^{11} dynes cm^{-2}, while the rigidity of water ice is $\mu = 4 \times 10^{10}$ dynes cm^{-2}. A volatile poor Titan would have a rigidity of several $\times 10^{11}$ dynes cm^{-2}. On the other hand, an internal ocean in Titan would mechanically decouple the outer solid layer from the inner mantle and core and the expected value of μ would be approximately ten times smaller. We have investigated the periodic deformation of Titan for different models of internal structure, in particular how the internal ocean affects the parameters k_2 and μ and the Doppler observable; we also discuss how Doppler measurements can discriminate between different models.

PREBIOTIC-LIKE CHEMISTRY ON TITAN : LABORATORY OBSERVATIONS AND SPECULATIONS

F. RAULIN, Y. BENILAN, P. COLL, M.-C. GAZEAU, L. GUEZ and P. BRUSTON (LISA, Universités Paris 7, Paris 12 & CNRS, C.M.C., 61 av. du Général de Gaulle, 94010 Créteil cedex, France).

Organic chemistry on Titan and prebiotic chemistry on Earth involve the same N-containing organic molecules : nitriles, including acetylenic nitriles and dinitriles, and their oligomers. Thus, in spite of much lower temperatures and the absence of liquid water, because of its environment very rich in organics, and the many couplings involved in the various parts of its "geofluid", Titan is a reference laboratory for studying prebiotic chemistry on a planetary scale.
Together with theoretical modeling and observational approaches, laboratory experiments provide a very powerful way to study such a chemistry. Simulation experiments allow to predict the nature and relative abundances of trace constituents in the gas and solid phases and provide analogues of Titan's atmosphere allowing the calibration of in situ and remote sensing instruments. Experimental spectroscopic studies provide the reference data essential to detect the atmospheric candidate molecules and determine their abundances The latest data relative to Titan's organic chemitry, including gas phase and solid phase laboratory data, using those complementary tools will be reviewed.

THE PHOTOCHEMISTRY OF TITAN

P.N. Romani (NASA – Goddard Space Flight Center, Greenbelt, MD 20771 USA)

Présent in the atmosphere of Titan are trace amounts of hydrocarbons, nitriles, and oxygen compounds. Knowledge of the sources and sinks of these species is vital to an understanding of Titan's atmosphere because they are important for aerosol formation and controlling the thermal structure and chemical evolution of the atmosphere. The ultimate source of these species is the photolysis of and charged particle impact upon Titan's background N_2–CH_4 atmosphere. Thus, there have been many photochemical modeling studies of Titan, with increasing complexity (numbers of reactions). But, comparison of model predictions to observations shows that to date Titan photochemistry is still an unsolved problem; no model can predict the mixing ratio profiles of all of the trace species to within the uncertainties of the observations. Ways to address this problem will be examined by simple modeling in light of recent laboratory studies and observations.

CONDENSATION AND PRECIPITATION PROCESSES IN TITAN'S ATMOSPHERE

Robert E. Samuelson (Goddard Space Flight Center, Greenbelt, MD 20771, USA)

Analysis of Voyager 1 IRIS spectra of Titan's springtime north polar hood suggests a seasonally cyclic process. During the winter there is a build-up of C_4N_2 vapor in the stratospheric polar shadow. As spring approaches, C_4N_2 is rapidly depleted by photolysis above the sunlight/shadow boundary. Simultaneously there is a progressive build-up of condensate lower down in the region of dropping temperature and persisting shadow. This combination of processes leads to a large excess of C_4N_2 condensate relative to the abundance of vapor above it. Other nitriles should exhibit similar behavior. Because nitrile ices are slightly soluble in ethane, nitrile cloud particles act as seed nuclei for ethane condensation in the lower stratosphere. In turn, the precipitation of condensed ethane into regions of methane supersaturation in the upper troposphere induces methane condensation there. Rapid growth and precipitation of methane particles occur throughout the region of high supersaturation. Once regions of subsaturation are reached lower down, particle evaporation is rapid. An ethane-methane mist slowly settles to the polar surface, leading to an enrichment of ethane in the surface liquid relative to that at low latitudes. Vapor pressure equilibrium with the surface requires a reduction of the methane vapor mole fraction at high latitudes compared with that in equatorial regions, a prediction apparently borne out from analysis of the 200 - 600 cm^{-1} IRIS spectral continuum.

STRUCTURE OF TITAN'S STRATOPSHERE FROM THE OCCULTATION OF 28 SGR

B. Sicardy (Obs. and Univ. Paris/IUF, 92195 Meudon Cédex, France)
F. Ferri (Univ. di Padova, Italy)

The occultation of the bright star 28 Sgr (V=5.5) by Titan on July 3, 1989 provided an exceptional opportunity for probing the atmosphere of Titan between the altitudes $\sim$ 250 and 500 km ($\sim$ 1-250 μbar). A dozen good quality light curves yield ingress and egress cuts in the atmosphere, with mutual separations ranging from 15 to 1700 km. Also, the star was continuously detectable as it probed *horizontally* the limb of the satellite at an altitude of $\sim$ 260–300 km, depending on the station.
Two inversion layers are clearly visible at altitudes of 425 and 455 km in all profiles, and are thus global features. Localized structures are also observed, with negative gradients $\partial T/\partial z$ saturated by the adiabatic lapse rate. The correlation between these smaller structures drops over a scale of $\sim$ 300 km in the *horizontal* direction. The vertical power spectra of $T(z)$ exhibit a power law behavior with index q close to -3 between frequencies $\sim 100^{-1}$ and 10^{-1} km^{-1}, reminiscent of saturated gravity wave spectra in the Earth's stratosphere. Spectra of horizontal structures of $T(x)$ in the 260-300 km altitude range will also be presented.
Finally, the density profiles $n(z)$ in the altitude range 330–470 km do not show local deviations larger than 5% relative to a smooth exponential atmosphere. Effects on the *Huygens* probe during entry are estimated.

ON THE PRESENCE OF A DEEP OCEAN WITHIN TITAN

C. Sotin, O. Grasset, and A. Mocquet (Laboratoire de Géophysique et de Planétologie, Faculté des Sciences, B.P. 92208, 2 rue de la Houssinière, 44322 Nantes cedex 3, France).

The composition of the atmosphere and the surface caracteristics of Titan are linked to its internal dynamics and structure. It strongly depends on the efficiency of heat transfer by convection through the outer ice I layer. Current models of accretion suggest that the internal structure of Titan just after accretion is composed of three layers : a silicate core, a liquid shell and a outer ice I layer. We have carried out numerical models of the thermal evolution and internal structure of Titan which take into account the strongly temperature dependent viscosity of ice I and the possible presence of chemical compounds in the ocean that change the value of the melting curve. It is shown that if only H20 is present in the ocean, then the convection process is very efficient in the ice I layer and the satellite would completely freeze in a billion years. On the other hand, the presence of chemical coumpounds (like NH3) which decrease the freezing point of the ocean limits the efficiency of convection because the temperature of the ice I layer is smaller and its viscosity much larger. As a result, the thickness of the outer convecting ice I layer would be around 40 km, the deep ocean would still be present and the silicate core could be warm enough to start differenciate an inner iron core. Curent models are being developed to investigate the rigidity of the lithosphere and its possible faulting to release gases like CH4 in the present atmosphere. Love numbers and moment of inertia of Titan are calculated for these different models to assess wether the gravity data that will be acquired by the Cassini mission will help to constrain the internal structure of this satellite.

RATES AND PRODUCTS OF REACTIONS OF THE C_2H_3 FREE RADICAL IN THE ATMOSPHERE OF TITAN

L.J. Stief, W.A. Payne, F.L. Nesbitt, R.P. Thorn, P.S. Monks, X.F.D. Chillier (NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA)

The C_2H_3 free radical is one of the most abundant radical species in photochemical models of the atmosphere of Titan. Important reactions of C_2H_3 are those with the atoms H and N and the free radicals CH_3 and C_2H_3. Our results have been published very recently for H + C_2H_3 (1995), N + C_2H_3 and C_2H_3 + C_2H_3 (1996); work in now in progress on CH_3 + C_2H_3 and will be reported at the symposium. The rate constant and product yield studies show that while the total rate constants for all four reactions are comparable to the hard sphere collision rate, the product yields display considerable variety. The largest impact of our rate results on models of Titan's atmosphere is that k(H+C_2H_3) is about five times faster than previously estimated. Formation of the C_2H_4 adduct in the reaction H+C_2H_3 was neglected in the models but we measure a branching ratio of 0.24 at T=213K and 1 Torr He pressure. Conversely, formation of the C_4H_6 adduct in the reaction C_2H_3+ C_2H_3 was included while we observe no C_4H_6 (<0.01) at 1 Torr He pressure. This research has emphasized the need to examine both rates and products of fast, multichannel atom+radical and radical+radical reactions important in models of the atmosphere of Titan.

THE COMPOSITION AND THERMAL STRUCTURE OF TITAN'S ATMOSPHERE AS INFERRED FROM ULTRAVIOLET OBSERVATIONS

D F Strobel (Dept. of Earth and Planetary Sciences, The Johns Hopkins University, 3400 N Charles St., Baltimore, MD 21218 USA)

This talk will review ultraviolet observations of Titan's upper atmosphere by the Voyager Ultraviolet Spectrometer, International Ultraviolet Explorer, and the Hubble Space Telescope. From these observations the composition and thermal structure of Titan's upper atmosphere can be derived and deductions about magnetospheric power input can be inferred. Combining ultraviolet and infrared observations and inferred composition yields information on the vertical mixing rates from the tropopause up to the homopause.

SEASONAL VARIATION OF TITAN'S THERMAL STRUCTURE AS SIMULATED BY A RADIATI VE MODEL

T. Tokano, F. M. Neubauer and M. Laube (Institut für Geophysik und Meteorologie, Universität zu Köln, Albertus-Magnus-Platz, D-50923 Köln, Germany)
C. P. McKay (NASA Ames Research Center, Moffett Field, CA 94035, U.S.A.)

The seasonal cycle of the thermal structure of Titan has been simulated by a 2-d imensional application of the radiative model. It is shown that additional to Sa turn's obliquity, the orbital eccentricity of Saturn has a modest effect on the thermal structu re. Due to perihelion near southern summer solstice, the southern hemisphere is considerably warmer than the northern hemisphere in yearly mean, especially in t he upper stratosphere. The strong polar temperature variation follows the solar forcing with a small time lag while the slight equatorial temperature variation is controlled b y the true distance to the Sun. However, the thermal structure simulated for the time of Voyager 1 encounter does not coincide with the latitudinal structure me asured by Voyag er, indicating that the pure radiative model with horizontally homogenous and constant optical properties and without dynamics is alone not able to reproduce the atmosphere properly. The consideration of the spherical geom! etry for calculating the solar hea
ting rate could be of importance in polar regions since the plane parallel appro ximation would underestimate the heating rate at polar winter remarkably.

THE SCIENTIFIC OBJECTIVES OF THE DESCENT IMAGER/ SPECTRAL RADIOMETER (DISR) INVESTIGATION ON THE HUYGENS PROBE

M. G. Tomasko, L. R. Doose, P. H. Smith, B. Rizk, M. Lemmon (Univ. of Arizona, Tucson, AZ, USA), R. A. West (JPL, 4800 Oak Grove Dr., Pasadena, CA, USA), L. A. Soderblom (USGS, 2255 N. Gemini Dr., Flagstaff, AZ, USA), M. Combes, B. Bézard, A. Coustenis, C. deBergh, E. Lellouch (DESPA, Obs. de Paris, Meudon, France), B. Schmidt (Lab. de. Glaciologie et Géophysisque de l'Environne ment, Grenoble, France), H. U. Keller, N. Thomas (Max Planck Institut für Aeronomie, D-3411 Katlenburg-Lindau, Germany) and F. Gliem (Technische Universität Braunschweig, Braunschweig, Germany)

The DISR investigation has scientific objectives in four broad areas: 1) measurement of solar energy deposition profile for thermal balance studies; 2) measurement of the distribution and optical properties of haze and cloud particles; 3) measurement of the mixing ratio profile of methane; and 4) determination of the physical state, topography, and composition of the surface and characterization of the physical processes that form the surface and govern its interaction with the atmosphere. The suite of measurements will be summarized, and the links between the measurements and the scientific goals of the investigation will be reviewed. A poster will summarizes the key features of the DISR instrument and its measurement capability.

TITAN'S ATMOSPHERE AND IONOSPHERE: IMPLICATIONS FOR THE PRODUCTION OF AEROSOLS

D. Toublanc (Observatoire Midi-Pyrénées, Toulouse, France)
J. Lilensten, M. Galand (CEPHAG, Grenoble, France)
C. McKay (NASA Ames, Mountain View, CA, USA)

In order to understand the electron density observed on Titan, and the formation of organic haze we have coupled three different models of Titan's atmosphere:

the neutral photochemical model of Toublanc et al. 1995
the ionosphere model of Keller et al. 1992
the microphysical model of Toon et al. 1992

The major neutral species, nitrogen and methane, are ionized by solar EUV flux and electron impact. The net production of primary ions is computed using a kinetic transport model adapted from terrestrial case. A complete set of reactions involving neutrals, ions, and electrons is then used to compute all the density profiles. As we will discuss the electron density profile is driven by a very small number of reactions, we have to choose carefully.
Another interesting fact is that ions can stimulate the formation of big aggregates which account in the general scheme of aerosols' formation. We will discuss several cases and their consequences for the profile of aerosols.

SCANNING ELECTRON MICROSCOPY OF TITAN AND TRITON THOLINS

E. de Vanssay, G. McDonald, C. Sagan and **E. de Vanssay** (LPS, Space Science Building Cornell University)
B. Khare (Ames Research Center)

We have been examining the structures of Titan and Triton tholins, to about 0.1 μm effective resolution, using a state-of-the-art Hitachi scanning electron microscope. Sample electron micrographs for both Titan and Triton tholins have been obtained. They show a wide variety of structures dominated by spherical particles of about 1 μm diameter size. Some of these are broken and display a central cavity or a core. The general morphology of these particles seems to be compatible with a density low enough to float on the surface of low density putative hydrocarbons lakes on the surface of Titan. We have also compared the size distributions of tholin particles with those synthesized from N_2/CH_4 mixtures by UV irradiation (Scattergood et al., 1992, Icarus, 99, 98; Bar-Nun et al. 1988, JGR, 93, 8383) and in closed vessel spark discharge experiments (de Vanssay, 1994, Ph.D. thesis, Universite Paris7). The mean diameter is about 2 times smaller with the UV irradiation than with particles obtained through an inductively coupled plasma discharge. Our comparison shows a wide range of variation of the mean diameter with experimental parameters with no direct correlation between particle size and experimental parameters.

CASSINI ION NEUTRAL MASS SPECTROMETRY MEASUREMENTS AT TITAN

J. H. WAITE, JR., Southwest Research Institute, PO Drawer 28510, San Antonio TX 78228-0510 USA; T. E. Cravens, University of Kansas, Lawrence KS 66045; W-H. Ip, Max-Planck-Institut fuer Aeronomie, D-37189 Katlenburg/Lindau, Germany; W. T. Kasprzak, NASA Goddard Space Flight Center, Greenbelt MD 20771; J. G. Luhmann, University of California, Berkeley CA 94720; R. L. McNutt, Applied Physics Laboratory, Laurel MD 20723; R. V. Yelle, Boston University, Boston MA 02215; H. B. Niemann, NASA Goddard Space Flight Center, Greenbelt MD 20771; and V. G. Anicich, Jet Propulsion Laboratory, Pasadena CA 91109

The Ion and Neutral Mass Spectrometer (INMS) onboard the Cassini orbiter will obtain ion and neutral mass composition information on Titan's upper atmosphere during most of the scheduled 30 to 40 close approaches of the Cassini spacecraft by Titan. The use of an open and closed ion source on the instrument allows a sensitive determination of both inert and reactive ion and neutral species between 1 and 99 Daltons. In addition to ion and neutral composition data, the altitude-dependent abundances can be used to deduce scale heights of the constituents and thereby temperatures in the upper atmosphere. Limited energy and angle resolution may also allow the determination of ion flow velocities. This talk will focus on the characteristics of the INMS and the anticipated results, including simulations of anticipated Titan flybys.

NEAR IR SPECTROSCOPY OF IAPETUS : SEARCH FOR ORGANIC MATTER

R. Wittemberg and A. Coustenis (DESPA, Paris-Meudon Observatory, FRANCE)
B. Schmitt (L.G.G.E, Grenoble)
J-G. Cuby (ESO, Garching)

The surface of Iapetus has been investigated in 1996 using the ISIS spectrometer at the CFHT which operates in the near IR range (1. - 1.8 micron).
One of the most mysterious among the icy Saturnian satellites, Iapetus is unique in its range of surface albedos, from 0.5 on the trailing side (typical of icy objects) to 0.02-0.04 in the inner parts of the leading hemisphere. This albedo asymmetry is not unique in the Solar system, as Titan and Hyperion present such a property, which might be indicative of a common origin.
The nature and the origin of the dark component has not been elucidated yet, but according to some models, this is possibly connected with the presence of organic material on the surface.
We have tried to detect organic lines on the leading side of Iapetus with ISIS in the 1.4-18 micron range, where some signatures of most of the expected organic components (Polymers, tholins and other hydrocarbons) are located.
Data are currently under reduction, and we will present the results, and discuss the relevance with Titan.

NEW WF/PC2 IMAGES OF TITAN: MAPS OF TITAN'S SURFACE AND TROPOSPHERE

E. F. Young and C. P. McKay (NASA Ames Research Center, MS 245-6, Moffett Field, CA 94035, U.S.A.)
C. A. Griffith (Northern Arizona University, Dept. of Physics and Astronomy, Flagstaff, AZ 86011-6010)
K. Noll (Space Telescope Science Institute, 3700 San Marin Drive, Baltimore MD 21218)
T. Owen and B. Han (University of Hawaii, IfA, 2680 Woodlawn Dr., Honolulu, HI, 9)

We present spatially-resolved maps of optical depth for several levels in Titan's atmosphere. These maps are based on HST images taken in October, 1996 at six wavelengths ranging from 887 nm to 953 nm and a seventh at 619 nm. Methane's absorption coefficient varies by four orders of magnitude across these various filters. A bright area that may be a surface albedo feature is visible in the 928 and 940 nm images. The 887, 902 and 916 nm images are limb-brightened. The south polar region is brightest in all wavelengths and at all rotational phases. Simultaneous groundbased observations taken at 1.5 and 1.7 microns help separate the optical depth due to methane from that due to aerosols.

VERTICALLY-RESOLVED HAZE AND METHANE DISTRIBUTIONS IN TITAN'S ATMOSPHERE DERIVED FROM IR SPECTRA OBTAINED DURING ECLIPSE EMERGENCE

E. F. Young and C. P. McKay (NASA Ames Research Center, MS 245-6, Moffett Field, CA 94035, U.S.A.)
B. Han (University of Hawaii, IfA, 2680 Woodlawn Dr., Honolulu, HI, 96822)

We observed Titan emerging from Saturn's shadow several times during the 1995 Saturn ring-plane crossing season. Two of these events were observed from 0.8 to 2.5 microns using the KSPEC cross-dispersed spectrograph. The time resolution of $\approx$ 75 sec per spectra allowed us to separate Titan's disk into eight swatches with roughly N/S orientations.
The spectra obtained from swatches near Titan's limb represent photons reflected from higher in Titan's atmosphere than spectra obtained from Titan's disk center. Since our spectra include methane bands at 0.89 microns (where aerosol scattering is significant) and at 2.3 microns (where aerosol scattering is much less), we can determine the separate optical depths due to methane and haze at several altitudes.

STUDIES OF TITAN'S IONOSPHERE AND MAGNETOSPHERIC INTERACTIONS USING THE CASSINI PLASMA SPECTROMETER

D.T. Young (Southwest Research Institute, P.O. Drawer 28510, San Antonio, TX)
R.A. Baragiola, J.J. Berthelier, M. Blanc, A.J. Coates, R. Goldstein, M. Grande, T.W. Hill, V. Kelha, D.J. McComas, K.R. Svenes, K. Szegö, E.C. Sittler, P. Tanskanen

Cassini will fly through Titan's ionosphere approximately 35 times, mostly at altitudes < 1300 km. Several features of the Cassini Plasma Spectrometer (CAPS) have been designed to address the study of Titan's ionosphere and to investigate the interaction of Titan's ionosphere and wake region with Saturn's magnetosphere and the solar wind. CAPS will produce high mass resolution ($M/\Delta M = 80$) studies of ionospheric composition over the range 1 to 64 amu/e complemented by energy and angle resolved measurements of ions and electrons down to ~ 1 eV in the instrument frame. Science issues to be addressed include formation of the ionosphere, slow-mode shocks (if extant), and processes involved in the creation of Titan's wake.

THE CASSINI PLASMA SPECTROMETER (CAPS) INVESTIGATION

D.T. Young (Southwest Research Institute, P.O. Drawer 28510, San Antonio, TX)
R.A. Baragiola, J.J. Berthelier, M. Blanc, A.J. Coates, R. Goldstein, M. Grande, T.W. Hill, V. Kelha, D.J. McComas, K.R. Svenes, K. Szegö, E.C. Sittler, P. Tanskanen

Three separate sensors make up the Cassini Plasma Spectrometer (CAPS): the Electron Spectrometer (ELS) (0.7 to 30,000 eV, 6° x 160° field-of-view (FOV)), the Ion Beam Spectrometer (IBS) (1 to 50,000 eV, 2.1° x 150° FOV), and the Ion Mass Spectrometer (IMS) (1 to 50,000 eV/e, 1 to 64 amu/e, 11° x 160° FOV). The ELS and IBS are electrostatic energy/angle spectrometers while the IMS uses a unique electrostatic isochronous time-of-flight mass spectrometer with mass resolution ($M/\Delta M$) of 80. All three have high sensitivity and are capable of 2-D spectral time resolutions of 0.5 s (IBS), 2.0 s (ELS), and 4.0 s (IMS). In addition, the entire CAPS instrument rotates about its own base by ±104° at a rate of 1°/s thereby obtaining ~ 2π sr coverage of the sky during periods when the Cassini Orbiter is stationary.

THE HUYGENS SURFACE SCIENCE PACKAGE (SSP)

J.C. Zarnecki (Unit for Space Sciences and Astrophysics, University of Kent at Canterbury, England)
and the SSP consortium

The Surface Science Package (SSP) is one of the 6 instruments that are to be carried by the Huygens probe to Titan. The prime aim of the SSP is to study the surface rather than the atmosphere of Titan, although a significant atmospheric measurement capability is provided by the SSP. A suite of nine sensor subsytems is employed to make independent measurements of a wide variety of physical properties; temperature, thermal conductivity, speed of sound, and in the case of a liquid landing, density, refractive index, permittivity, sea depth and wave state, and for a dry impact site, surface hardness. The mechanical and electrical congfigurations of the instruments within the SSP will also be described.

A description will be made of the way in which the data from 9 sensors are combined in differing ways depending on the phase of Huygens' descent onto Titan's surface. Some calibration data from measurements made by the Flight Model SSP are also presented.

IMPRESSIONS OF TITAN FROM HUYGENS' SURFACE SCIENCE PACKAGE

J.C. Zarnecki (Unit for Space Sciences and Astrophysics, University of Kent, United Kingdom)
M.R. Leese, J.R.C. Garry, B.G. Hathi, N.A-L. Ghafoor, M.J. Wright (Unit for Space Sciences and Astrophysics, University of Kent, United Kingdom)

The Surface Science Pacakage (SSP) on the Huygens Titan Probe is the only one of the six experiments on board Huygens whose prime aim is the study of the surface rather than the atmosphere, although it does also have a significant measurement capability in the atmosphere. The SSP consists of a collection of nine measurement sub-systems designed to make various measurements of the physical properties of the surface at Huygens' landing site. In view of the fact that the nature of the surface is unknown - it is not even known if the surface is solid or liquid - the sensors were chosen in order to cover a range of surface types. The scientific return from the SSP will be discussed in light of the various possible surface types, indicating which sensors should return useful data in each of the major hypothesised surface scenarios.

PS5 Lunar exploration

Convener: Foing, B.H.
Co-Convener: Hoffmann, H.

A NEW CONCEPT FOR THE LUNAR MICROWAVE RADAR INSTRUMENT

M. Arcioni, G.Picardi, R.Seu

The Lunar Microwave Instrument (as proposed in MORO mission) can be designed to operate either as altimeter, interferometric SAR (Synthetic Aperture Radar) and radiometer, so that it is able to produce global topographic lunar maps and radar imaging and also lunar surface brightness temperature maps. As a matter of fact the following operative modes can be obtained: low resolution mapping (LRM) by using the radar altimeter in pulse-limited (PL) mode; high resolution imaging by using the SAR Interferometer (HRM-SAR); low resolution brightness temperature mapping by using microwave radiometer (RM). The first mode (LRM) provides three-dimensional mapping with coarse spatial resolution and very accurate measurement of the mean surface height and roughness, averaged over the resolution cell: the resolution performance can be improved in the along-range direction by using synthetic aperture approach with a proper ground processing (SASRA). In this paper is proposed an improvement by using interferometer mode also in altimeter operative mode to improve the resolution in the range direction. The analytical evaluations and the simulation results are shown. The hardware implementations are evaluated.

LUNAR PROSPECTOR'S POLAR ORBIT MAPPING MISSION

A.B. Binder (LRI, 1180 Sunrise Dr., Gilroy, CA, USA)

Lunar Prospector (LP) is the 1st peer reviewed, competitively selected mission in NASA's new "Faster, Better, Cheaper" Discovery Program. The spacecraft is drum shaped (1.4 m dia. x 1.2 m tall), has a 297 kg wet mass and carries the science instruments on three 2.5 m long booms. Launch on a 4 stage LMLV-2 rocket is set for early morning, Sept. 24, 1997, from Cape Canaveral. The translunar coast will take 123 hrs during which the boom will be deployed and science instrument calibration data will be collected. LP will be insertion into a 100 km altitude, 118 minute period, circular, polar mapping orbit by 3 nearly 1/2 hr burns spread over 2 days. The nominal mapping mission will last 1 year followed by a 6 month extended mission during which high resolution mapping will be done from 10 km x 100 km elliptical orbits. LP's science payload consists of the following: A Gamma-Ray Spectrometer to map the elemental (K, U, Th, Fe, Ti, Al, O, Si, Ca & Mg) composition of the surface; Two Neutron Spectrometers to search for polar ice deposits and map the H distribution in the regolith; An Alpha Particle Spectrometer to determine the frequency and locations of gas release events; A Magnetometer and Electron Reflectometer to map the lunar magnetic fields and determine if he Moon has an iron core. The Doppler tracking data will be used to map the lunar gravity field and determine if the Moon has a core.

New mission profils for lunar exploration.

Jacques BLAMONT - CNES/ PARIS

Lunar orbiters and landers can be sent cheaply from commercial launches in geostationary transfer orbits, by using "fuzzy boundary" trajectories. Concepts and limitations of the Miller-Belbruno transfer will be presented, with quantitative conclusions on the probe masses made available by this technique. Science objectives, instrumentation and types of spacecraft adapted to the mission will be discussed

A NEW REMOTE SENSING TECHNIQUE FOR ESTIMATION OF LUNAR REGOLITH THICKNESS

N. V. Bondarenko and Yu. G. Shkuratov (Kharkov Astronomical Observatory, 35 Sumska, Kharkov, 310022, Ukraine)

Known estimations of lunar regolith thickness had been based on the analysis of crater size frequency distributions and crater morphology. We propose a new remote sensing technique to estimate relative regolith thickness. We use optical and radar data and apply the one demension model of multiple scattering of radar waves in the regolith layer covering the bedrock (1). From optical data we obtained a soil absorption index distribution over the lunar nearside. Estimations of the relative regolith thickness were made with radar data and the absorption index data. Our calculations have shown that the mean regolith thickness for Mare Serenitatis, Mare Tranquillitatis, and Mare Humorum appears to be 3.25m. This thickness for Maria Crisium, Vaporum, Nubium, Cognitum, for Sinus Aestuum, Sinus Iridum, and Oceanus Procellarum is 4.25m, whereas for Mare Frigoris, Mare Nectaris, Sinus Roris, and Sinus Medii it is of 9.0m. These estimations are in agreement with estimations of the mean thickness of fragmented layer given by Oberbeck (2).

(1) Bondarenko N. V. and Shkuratov Yu. G., Astron. Vestn. 1997, in press.
(2) Oberbeck V. R. and Quaide W. L., Icarus, 1968, 9, 446.

ON A NATURE OF SPECTRAL ABSORPTION FEATURES OF SELECTED LUNAR SITES

V.V. Busarev (Sternberg State Astron. Inst., Moscow 119899, RUSSIA)

As it follows from telescopic observations of selected lunar mare and adjacent sites with resolution of 10-30km [1-3], weak absorption bands present often at 470-590, 590-620, and 700-800nm in the reflectance spectra. But they do not quite agree with spectral curves of a higher spatial resolution (e.g., [4]) of uniform mare areas and with spectral features of returned lunar soil samples, mineral separates, fines, and glasses [5]. The phenomena may be explained if one takes into account: 1)the telescopic reflectance spectra under the lower resolution represent lunar areas covered with materials which are not purely mare and include highland ones; a common silicate matrix of such mixure is more light and transparent and allows rising of specific spectral features of minerals and agglutinates in an overall reflectance spectrum: 2)the spectral features could reflect original physical conditions (pressure and/or temperature) of minerals and/or glassy phases which influence on parameters of their coordination polyhedra including coexisting Fe(2+), Ti(3+), and Ti(4+) ions and the metal-metal distances; 3)there is a mechanism of liquation of Al-Fe-Ti-silicate glasses [6] accounting for isomorphic type substitutions of Al(3+)-> Ti(3+), 2Al(3+)-> Fe(2+) + Ti(4+), reducing on an average the metal-metal distances, development of charge transfer transitions between the ions, and hence strengthening the corresponding spectral features.

The Clementine Control Network of the Moon and Improving the Accuracy of Coordinates

Davies, M. E., Colvin, T. R., RAND, Santa Monica, CA
Becker, T. L., Lee, E. M., U.S.G.S., Flagstaff, AZ

The Clementine control network was computed from 543248 measurements of 271635 points on 43871 pictures covering the entire lunar surface. The radius was assumed to be 1736.7 km.

Davies et al., 1987 computed a best fit of the Apollo control network to the Apollo 15, 16, 17 ALSEP coordinates. The coordinates of 22 points from this network were held fixed in the Clementine adjustment because they were known to be very accurate.

Maps of all of the Apollo lander sites have been produced and locate the LRRR/ALSEP points relative to craters and other topography. Thus, if high resolution images are taken by future spacecraft, the LRRR/ALSEP coordinates can be introduced into the control computations thus improving the accuracy of coordinates over an expanded region.

A NOVEL RADAR INSTRUMENT FOR PLANETARY ROVER PILOTING AND SUBSURFACE EXPLORATION

Hans Martin Braun, Harald Lentz, Peter Putz, Alan Wood, Bernard Forkmann

Under the acronmym GINGER - Guidance and Into-the-Ground Exploration Radar - a new Radar development was started by the European Space Agency in 1994. This Radar was aimed to support piloting of a planetary Rover by medium resolution imaging of the surface in front detecting obstacles, measuring the forward and sideward speed of the Rover, and estimating the traversability of the planetary surface before the Rover is driving accross. Surface and subsurface measurements are providing viable scientific data exploring the surface material in front and the subsurface layer structure beneeth the Rover. Surface Penetration Mode. Measurement goal is to contribute to the characterisation of subsurface soils, to measure subsurface layers, bedrock, etc. down to app. 10m with a range resolution of <0.5m and to detect small size inclusions of high reflectivity. Speed Measurement: Two small Radar antennas operating at 60 GHz measure the Rover speed over ground in two perpendicular directions by analysis of the Doppler shift in the Radar echoes. Obstacle Detection: The same 2 Radar antennas, fixed at the right and the left front corner of the Rover, receive echoes from obstacles in the way. Soil Traversability Estimation: The Radar operates above 10 GHz and below 1 GHz in parallel. After relative phase calibration of the high frequency and the low frequency channels on hard surfaces, the Radar echo phase difference is strongly diverting, if the echoes are coming from weak terrain. On behalf of ESA, an industrial team led by RST Raumfahrt Systemtechnik, had developed a technology demonstrator of this Radar.

THE TOPOGRAPHY OF THE MARE ORIENTALE IMPACT BASIN

A.C.Cook, H.Hiesinger and M.Wählisch (DLR, Institute of Planetary Exploration, Rudower Chaussee 5, D-12489 Berlin, FRG)

A Digital Elevation Model (DEM) covering most of the Mare Orientale impact basin (120°W-65°W, 40°S-0°N) has been generated at a spatial scale of 1km per pixel using the weak stereo present in mostly-nadir pointing Clementine UVVIS images. Each image pair was matched automatically and then ray traced through a stereo intersection camera model, using nominal camera pointing. For each pair, the resulting tile of relative height points was fitted iteratively to existing laser altimetry profiles and/or adjacent tiles. The DEM produced (1738km radius datum used) indicates that the region of the mare flooded inner floor of the basin, of diameter 350km and -3km elevation, slopes to the south west at a gradient of 1%. The inner Rook ring (350-500km diameter) has an elevation of about 0km. The outer Rook ring, of diameter 600-720km, rises to about +2km in elevation. The third ring, starts at a diameter of about 900km but merges into the surrounding terrain. Its highest point, in excess of 6km elevation, lies on the west (113°W, 15°S). The third ring's eastern side is on average 2.5km lower than its western side. In the south east the ring is cut by radial gullies, of which Vallis Bouvard is the deepest at 3.5km. The bottom of the crater Maunder forms the lowest elevation point in the basin: -5km. This and many other craters, visible in the DEM, have had their profiles measured (e.g. Lowell, Shaler, Blackett, and Schlüter). Cross-sectional profiles taken through the basin and its craters, as well as comparisons of other remote sensing datasets in relation to the topography, will be presented.

Lunar exosphere

R.Gabryszewski, M. Rataj (Space Research Centre, ul. Bartycka 18A, 00-716 Warszawa, Poland)

Abstract. Our knowledge of the Moon's exosphere is rather narrow. Prior to 1988, only late Apollo missions detected marginal quantities of atoms and molecules: H,O,N,C,Kr,Xe,H2,CO and some others.Up to now only ground-base observations of lunar sodium have been made. They are insufficient to build a complete, real model of lunar sodium atmosphere (ie: transport dynamics of sodium atoms upon accelerations, gas-surface interactions, lifetime of sodium atoms in the atmosphere of the Moon, sources). Ground-based observations are not always possible, they are limited by geometric and atmospheric factors, collected data are not homogeneous. Space Research Centre of Polish Academy of Sciences is able to build a small, low power consuming sodium sensor which can be put on LunarSat board. That detector could gather all important informations to construct the new model of sodium atmosphere in 30 to 90 days. Collected data would be homogeneous and geometry-independent. We would also be able to measure the sodium atmophere upon the far side of the Moon. It would be the first experiment detecting Moon's sodium from a satellite. The information which could be gathered by that sensor will help us to construct the complete lunar sodium atmosphere model We will also be ascertain what the global morphology of lunar atmosphere is. It should be remembered that all primitive bodies in Solar System such as Mercury or most moons of planets have similar atmospheric conditions, so these researches could have a vital meaning not only for future lunar missions but also for missions to other moons, comets and asteroids (Cassini/Huygens, Rosetta, mission to the comet Wild 2 etc)

LUNAR MARE VOLCANISM: GEOLOGICAL EVIDENCE FOR ONSET, DISTRIBUTION, DIVERSITY AND DURATION AND IMPLICATIONS FOR PETROGENETIC MODELS

James W. Head (Dept. of Geol. Scis., Brown Univ., Providence, RI 02912 USA)

Geologic mapping, petrologic analysis and remote sensing data have provided constraints on models for the formation and evolution of mare basalt source regions, the ascent and behavior of basaltic source materials, and the final emplacement of mare basalt magmas on the surface. Increasing detection of cryptomaria has clearly demonstrated that mare volcanism began and was areally extensive prior to the formation of the last large impact basin at about 3.8 Ga. Mare basins are characterized by a diversity of basalt fill; temporal heterogeneity is at least as important as sequential heterogeneity. The vast majority of observed volcanic deposits were emplaced in the Late Imbrian Period, spanning 600 Ma from about 3.8 to 3.2 Ga. During this time, a wide range of basaltic compositions was being emplaced in virtually all the nearside mare basins, with earliest and intermediate deposits dominated by (but not confined to) high-Ti basalts; later deposits of this period are dominantly low-Ti and represent the major late fill of the nearside basins. The age of the latest mare volcanism may be as young as Copernican. Thus, mare basalts formed over a period of at least 2 Ga; however, surface volcanism has not been volumetrically significant on the Moon since about the late Archean on Earth. Extensive lava flows, sinuous rilles, and lack of large shield volcanoes suggest that magmas are commonly delivered to the surface in large quantity, through dikes originating from depth; ascending diapirs are likely to stall at a neutral buoyancy zone at the base of the crust before reservoir overpressurization propagates dikes toward the surface. Petrogenetic models involving gravitational overturn of magma-ocean Fe-rich cumulates and the predicted aftermath are broadly consistent with these observations.

THE DARK RING IN THE SOUTHWESTERN ORIENTALE BASIN: AN IO-LIKE PYROCLASTIC ERUPTION ON THE MOON?

J. W. Head (Dept. Geological Sciences, Brown Univ., Providence, RI 02912 USA), C. M. Weitz (Brown Univ.) and L. Wilson (Planetary Science Group, Institute of Environmental & Biological Sciences, Lancaster Univ., Lancaster UK)

A large, 154-km-diameter dark ring along the Montes Rook in SW Orientale Basin has previously been interpreted as a ring of localized dark mantle deposits formed at vents located at the position of an ancient pre-Orientale-basin impact crater scar. On the basis of examination of the geology of the region and Clementine multispectral data, we propose that the dark ring is the manifestation of a pyroclastic eruption originating at a central vent, in a mode similar to that observed in the pyroclastic rings on the Galilean satellite Io. Location of a candidate for the central vent in the form of an elongate 7.5 km by 16 km depression strengthens this interpretation. We model the eruption as involving a dike emplaced to within about 3-4 km of the surface which stabilized and degassed to form an upper foam layer which then penetrated to the surface to cause an eruption. The eruption produced a symmetrical spray of pyroclasts into the lunar vacuum at velocities of ~420 m/s, and the pyroclastic material accumulated in a symmetrical ring around the vent. The geometry of accumulation caused the deposits to accumulate preferentially in a ring representing the material ejected at 45 degrees. Clementine multispectral data confirm that the dark ring consists of glass similar to pyroclastic glasses most closely related to those that comprise the Aristarchus Plateau. The paucity of pyroclastic rings of this type on the Moon can be attributed to the low probability of a dike stalling at just the right depth (about 3-4 km) to create these eruption conditions. The detailed characteristics of this ring provide important new insight into the emplacement of pyroclastics in the more regionally continuous lunar dark mantle deposits.

THE MAUNDER - KOPFF CRATER PARADOX: ANALYSIS USING CLEMENTINE DATA

J. W. Head (Dept. Geological Scis., Brown Univ., Providence, RI 02912 USA), C. M. Weitz and C. M. Pieters (Brown Univ.), G. Neukum, J. Oberst, H. Hiesinger, A. Cook, and M. Wahlisch (DLR, Berlin, Germany)

Ever since the interior of the Orientale basin was imaged by Lunar Orbiter, the contrasting characteristics of the craters Maunder and Kopff have been a paradox. Kopff is a unique 41-km-diameter crater whose characteristics lie in distinct contrast to a typical impact crater such as Maunder (52 km), only about 100 km away. Previous interpretations of Kopff include formation as a volcanic explosion crater or collapse caldera, or as an impact into thin crust and lithosphere and/or Orientale impact melt mush. We use new Clementine topography (altimetry/stereo/DEM) and UVVIS multispectral data to characterize Kopff and to assess its origin. The Kopff crater floor is 1.6 km below the rim crest, has no central peak and is shallower than Maunder (1.5-2.0 km shallower than a typical fresh impact crater); its wall is relatively simple but has some slump blocks at its base similar to wall slumps in smaller transitional craters such as Dawes. Mare deposits, linear rilles, and small dark-halo craters occur on the floor consistent with shallow intrusion beneath the crater floor and some extrusion. The crater rim crest is sharp and relatively unbroken and the rim appears to be steeper (rim height of 950 m) and smoother than that of a typical impact crater, particularly when compared to Maunder. A deposit of relatively smoother material blankets the pre-Kopff deposits and extends out to about a crater radius; there is little evidence for associated distal secondary craters and the SE quadrant of the rim deposit has unusual albedo and color characteristics. We interpret Kopff as a volcanically modified impact crater, whose initial impact characteristics were similar to craters in the simple-complex transition (e.g., Dawes).

ON THE AGES AND COMPOSITION OF LUNAR MARE BASALTS

H. Hiesinger, R. Jaumann, G. Neukum (DLR, Institute of Planetary Exploration, Rudower Chaussee 5, D-12489 Berlin, Germany)

Lunar volcanism lasted for about 1.5 b.y. and ceased at approximately 2.5 b.y. ago. This implies that the temperature of the lunar mantle had then dropped below 1100 °C, necessary to produce basaltic melts on the Moon. From multispectral data sets it is also known that basalts on the lunar surface exhibit a broad variety in their composition, ranging from very low titanium (< 1 wt%) to high titanium (> 6 wt%). Investigation of the composition and the age of lunar mare basalts as well as estimates of their volumes allow to model the state and evolution of the Moon over time. In this context it is important to know, whether there exists any systematic relation between the age of a lunar basalt and its geochemical-mineralogical composition. Ages which are mainly based on stratigraphic superposition of units are often not precise enough or even wrong and therefore misleading for this investigation. In order to quantisize the relationship between age and composition, new age determinations had to be obtained. We performed numerous crater counts on high resolution Lunar Orbiter IV images in combination with multispectral Galileo data from the Earth/Moon-Encounter 2. Our approach was to determine the ages for units which have been spectrally defined in a color ratio composite based on the Galileo data. From this data set we also calculated the mean titanium content of these units according to the empirical relation between the titanium content and the UV/VIS ratio. Results of this investigation will be presented for the Imbrium-, Serenitatis-, and Tranquillitatis basin, respectively.

JAPANESE LUNAR EXPLORATION PROJECT "SELENE"

Haruaki Itagaki, Yoshisada Takizawa
National Space Development Agency of Japan
Susumu Sasaki
The Institute of Space&Astronautical Science

NASDA has a plan to launch "SELenological & ENgineering Explorer (SELENE) " in cooperation with ISAS. SELENE system consists of an orbiter, a lander and a relay satellite. The orbiter equipped with 14 mission instruments is injected into the lunar polar orbit (100 Km altitude).
Major objectives are to obtain scientific data of the lunar origin and evolution and to develop the technology for the future lunar exploration. SELENE will be launched by H-IIA vehicle in 2003.

SPECTRAL CHARACTERISTICS AND AGES OF LUNAR LIGHT PLAINS NORTH AND EAST OF MARE FRIGORIS

U. Kochler, G. Neukum (DLR, Institute of Planetary Exploration, Rudower Chaussee 5, D-12489 Berlin, Germany)

Before the Clementine mission, our knowledge of the nature and origin of lunar light plains was based primarily on the interpretation of the Apollo and Lunar Orbiter images of the Cayley Plains, i.e. the Apollo 16 landing site and the areas extending to the west. Apollo 16 ground truth gave reason to explain the origin of these unusual smooth and brighter-than-mare plains in an impact-ejecta context, mainly related to the last two basin-forming events on the Moon (Orientale, and/or Imbrium impact). In addition, we determined ages of a number of light plains through crater-frequency measurements, giving us some ages significantly younger than the Orientale event, the last major basin-forming impact. Therefore we have reason to believe that endogenic (volcanic) processes contributed to the formation of these plains. We have extended our age measurements to light plains at the eastern margin of Mare Frigoris and to units in the Meton area. By combining Lunar Orbiter and Clementine images we have been able to get new age data in the investigated areas, and which a) cannot exclusively be related to the Orientale or Imbrium event, respectively, and b) in some cases is younger than the Orientale event. Clementine and Galileo multispectral data of the northern plains revealed that we deal (in spectral terms) with two different surface types, one rather mare basalt-like type, the other with highland material affinities. This, together with our age data leads us to the conclusion that the origin of lunar light plains in general and these high-latitude nearside plains in particular are at least partially related to an endogenic origin, and that an exclusive impact-related origin is rather unlikely

THERMAL EVOLUTION OF THE LUNAR MANTLE AND THE THERMAL STATE OF THE CORE

W. Konrad and T. Spohn (Institut für Planetologie, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany)

The significance of mantle convection for the thermal evolution of the Moon is examined by solving the full hydrodynamic equations for the axisymmetric case. The viscosity depends on the mean radial temperature profile. Decay of radioactive isotopes, which are stongly enriched in the crust, is considered as the main internal heat source. The influence of a cooling core on the mantle convection pattern is investigated. The cooling of the Moon effects the growth of its lithosphere. Early in the evolution hot upwelling plumes originating at the hot core mantle boundary layer cause partial melting in the upper mantle. The duration of melting is connected to the initial lower mantle temperature. The core cools rapidly during the first billion years from a hot initial state thereby possibly causing a dynamo mechanism to explain an intrinsic early lunar magnetic field. The lower mantle does not cool significantly during the last 3 billion years preventing further cooling of the core. This might help explain the cessation of the lunar magnetic field during that epoch.

COMPOSITION OF THE MOON FROM GEOPHYSICAL CONSTRAINTS

O.L.Kuskov, V.A.Kronrod (Vernadsky Institute of Geochemistry)

The Moon is the only extraterrestrial body for which we have seismic data. The moment of inertia data suggest the existence of a core The problem to be solved is the internally consistent determination of the bulk composition of the Moon, the density distribution in the mantle and size of a core based on geophysical data, including the crustal thickness and density, the mantle seismic velocities, the moment of inertia and mass of the Moon. Phase equilibrium calculations as well as calculations of seismic velocities and density profiles in the CaO-FeO-MgO-Al_2O_3-SiO_2-Fe-FeS system have been undertaken to determine whether or not some of the bulk compositions and equilibrium assemblages match geophysical observations. The seismic data and moment of inertia constraints, combined with the phase equilibrium calculations, suggest the presence of a lunar core: 320-390 km in radius for the γ-Fe-core and 480-570 km for the FeS-core. The Moon's Fe/Si atomic ratio is equal to 0.22; this value is the lowest known Fe/Si ratio of any object in the solar system.

MELISSA : an ESA project of Artificial Ecosystem on the Moon.

Lasseur Ch., Verstraete, W., Gros J.B., Gaudia F., Richalet J. Dubertret G., Diels L.

One of the challenge of a mission to the Moon will be the the etablishment of an artificial ecosystem able to sustain human life. However, this final goal requires first a perfect understanding of the ecosystem behaviour in order to detect and control the influence of its new environmental conditions (radiations, reduced gravity, temperature, sun vailability,...). Based on the principle of an aquatic ecosystem, the MELISSA project is now studied by ESA for 7 years under the framework of a Memorandum of Understanding which involves several european universities, public and private organisations. The driving elements of MELISSA is the recovering of edible biomass from waste CO2, and minerals with the use of sun light as energy source. In this presentation we recall the structure of the MELISSA system, its interest in terms of a tool of understanding : its comprehensive structure (microorganisms and higher plant, anaerobic and photosynthetic metabolisms, multigeneration cultures..), and the associated engineering research (compartimentalisation, characterisation, modelling, automatic control,...). Then, we present the last technical and scientific results, the new facilities devoted to a ground demonstration, and the main orientations for the future. At the end, the status of a preliminary breadboard for microgravity experiments of a simplified version, based on the C cycle, is presented.

LUNAR CRUST STRUCTURE IN ALPHONSUS REGION.

Lelong C.C.D. , P.C. Pinet, S.D. Chevrel, Y. Daydou
(GRGS/UMR5562/OMP, 14 Av. Ed. Belin, 31400 Toulouse, France)

Alphonsus pre-imbrian-aged region (13°S, 2,5°W), with its complex geological history, is a good candidate to document the lunar ancient highland crust. Our work has consisted in a several-steps geological study of the region, mainly based on Clementine UV/VIS data. At first, the main units present in the region are defined on the basis of spectral and regional criteria. Then the iron content of the surface is mapped at 200 m resolution, to better constrain the geological units in terms of chemical composition. At last, principle component analysis identifies nine endmembers encompassing the whole regional spectral variability and used in an iterative spectral mixture analysis. It leads to a first attempt at deciphering the regional geology, resulting in the production of a simplified geologic map, and in possible interpretations in relation with the different units setting. In particular, a regional stratigraphic reconstruction is made and illustrated by cross-sections representing the proposed crustal structure. An obvious crustal contrast appears between the pre-existing targets of Alphonsus and Arzachel craters, the first being dominated by anorthosite while the second is ruled by norite. Our geological study of Alphonsus region emphasizes the existence of lateral variations in the compositional structure of the lunar crust, at the hundred kilometres scale, involving much more complex processes of crust formation than agreed at present.

EFFECT OF LUNAR SEISMIC ENVIRONMENT ON A MOON-BASED OPTICAL INTERFEROMETER

W. W. Mendell (SN2, NASA Johnson Space Center, Houston, TX 77058 USA)
M. J. Cintala (SN4, NASA JSC, Houston, TX 77058 USA)

Movement of the lunar surface from sources such as moonquakes, meteoroid impacts, and tidal flexure have the potential to degrade observations by an optical interferometer on the lunar surface. An ESA-sponsored analysis of the lunar environment (esa SCI(96)7, June, 1996) appears to overestimate degradation of performance due to meteoroid impacts and incorrectly represents the nature of lunar seisms. For example, the report predicts that within a few hundred meters of a telescope, there will be 563 meteoroid impacts per hour of sufficient magnitude to induce regolith motion with an amplitude >22.5 nm. By contrast, data at the Apollo 14 site (Duennebier & Sutton, JGR, 79, 4365) recorded only one impact every two years of this magnitude on the short-period instrument. The estimated radius of the area sampled by the seismometer is 50 km. Derivation of ground motion amplitudes from the published scientific papers is not always trivial, and connections between seismic observations and meteoroid flux is model-dependent. We derive relationships for relating meteoroid flux to ground motion, reviewing the impact model and updating earlier work on lunar seismic results.

Lunar Radar Sounder Experiment on-board SELENE Satellite

Takayuki Ono, and H. Oya (Department of Astronomy and Geophysics, Tohoku University, Sendai, Japan)

The Lunar Radar Sounder Experiment (LRS) on-board SELENE satellite has been planned to observe the subsurface structure of the Moon by using an HF radar method as an extended technique of the plasma sounder which has been developed for the plasma observation of the Earth's and Martian plasma environments. By using the radar technique in HF range, it becomes possible to detect the echoes from deep subsurface regions, comparing the UHF and micro-wave radars. The LRS is also aimed to observe the Solar and Planetary radio emissions' spectrum in detail and to identify their source regions. The main scientific objective of the subsurface sounding is to study on the Moon's tectonics. By measuring the subsurface structures down to the depth of several km range, LRS provides key parameters for following subjects, i.e.; 1) History of Temperature Profiles of the Moon's Body, 2) "Extra-Force" effects, 3) "Magma-Ocean" Hypothesis, 4) "Multi-Ring" formation, and 5) Geological Feature of Impact Craters and Volcanic Structures.

IRON, TITANIUM, AND MATURITY DISTRIBUTION ON THE MOON

N V.Opanasenko, Yu.G.Shkuratov, D.G.Stankevich, V.G.Kaydash, A.N.Najdyonov (Kharkov Astronomical Observatory, Sumskaya st, 35, Kharkov, 310022, Ukraine)

To map iron and titanium content and also the degree of maturity of the lunar surface, a technique by Lucey (1) was applied. For this aim, colorimetric and photometric images obtained by our telescope and Galileo spacecraft were used. Correlation diagrams: color-index C(0.95/0.75 um) - albedo A(0.75 mm) and color-index C(0.65/0.42 um) - albedo (0.65 um) show a complicated structure presented by some oblong clusters. For the first diagram, they are oriented approximately toward the point with coordinates C = 1.28, A = 0.09; this point is considered as the initial one in Lucey's technique. The coordinates were used to map iron content for the nearside and partially for the farside of the Moon. The second diagram was used to map titanium content for the same part of the lunar surface. A comparison of lunar surface maturity estimations using Lucey's (1) and Fisher-Pieter's (2) methods has been made. A correlation diagram for Pieter's and Lucey's maturity parameters shows that the average relationship between these is non-linear. Our map of iron distribution was used to study a correlation between iron content and remnant magnetism of the lunar surface. This relationship exhibits an inverse behavior: the lower iron content, the higher magnetism.

(1) Lucey P. et al Science. 1995, 268, 1150.
(2) Fisher E., Pieters C. J. Geoph. Res., 1996, 101, No.E1, 2225

LUNAR SCIENCE PROGRESS FROM NEW CLEMENTINE DATA

Carle M. Pieters (Geological Sciences, Brown Univ., Providence, RI 02912 USA)

Lunar science is moving into a new era of exploration with an international group of small missions to the Moon: Clementine, Luna-A, and Prospector. Contributions from Clementine were first derived from global topography and image datasets. Extremely useful global data products have been made available: crustal thickness maps, estimates of soil FeO, digital (albedo) reference maps @ 100 m and 1 km resolution. Since Clementine multispectral data require extensive processing, most research has initially focused on science topics addressed with local or regional data. Basin formation and evolution of the early lunar crust are particularly significant examples since they relate to the early history of the Earth-Moon system. The lunar crust below the megaregolith (> 5km) is shown to be very heterogeneous from Clementine spectral analyses of material excavated in central peaks of large craters. Relatively pure anorthosite is abundant (consistent with a magma ocean hypothesis), but the peaks of 50% of > 100 large craters are mafic or exhibit more than one rock type. The enormous 2500 km South Pole-Aitken (SPA) basin, known to exhibit a mafic anomaly from Galileo data, was perhaps the best candidate for excavation into the mantle. Recent Clementine mineral analyses of SPA interior, however, show no evidence for mantle mineralogy (no olivine nor high-Ca pyroxene), but instead indicate the low albedo surface of SPA represents an extensive noritic melt sheet formed from lower crustal materials. Such examples of Clementine analyses help to refine our thinking of lunar science issues. When integrated with Luna-A and Prospector data, we will have a foundation for a serious lunar exploration program.

THE LUNAR CHRONOLOGY AND IRON CONTENT FROM CLEMENTINE SPECTRO-IMAGING DATA

P. Pinet (UMR5562/GRGS/CNRS, 14, Av. E. Belin, Toulouse, 31400 France)
V.V. Shevchenko (Sternberg State Astronomical Institute, Moscow University, 119899 Moscow, Russia)
S.D. Chevrel (UMR5562/GRGS/CNRS, 14, Av. E. Belin, Toulouse, 31400 France)

A detailed remote sensing survey of the Reiner Gamma Formation (RGF), located in western Oceanus Procellarum, by means of Clementine multispectral dataset has been used to derive a lunar chronology index and weight percent of iron content in the lunar soils. A radiometric calibration has been made using telescopic and Galileo spectra, resulting in the production of absolute reflectance spectra. The spectral influence of both the soil maturity and iron content is quantified according to Lucey et al., 1995 and our previous analyses, based on the independent spectropolarization method, provide with soil maturity estimates in good agreement with the present results. The presence of extremely immature soils at the tens-meter-scale in the RGF area is revealed. The soil iron content into the area is higher (about 14%) than in the surrounding mare background surface (about 10%) and may be responsible for the RGF magnetic anomaly of which the origin is still unresolved. Using similar Clementine data for ten other lunar regions, we obtain a scale of conformity on maturity index estimates represented in the Lucey's modified diagram, in which we plot the Is/FeO index ranging from ~20 to ~80 and corresponding to exposure age from 10 to 100 million years. The most immature soils cover inner walls of young small craters and it points out at the occurrence of slope instability processes.

THE MOON - NATURAL STANDARD FOR CALIBRATION OF THE COSMIC IMAGES OF THE EARTH

S.G. Pugacheva, V.V. Shevchenko, (Sternberg State Astronomical Institute, 119899 Moscow, Russia)

The method where the Moon is used as a standard of calibration of spectrophotometric under-satellite observations is presented. Observations are produced by the satellite (GOMS), which was placed on geostationary orbit in October 1994 for meteorological forecasting and monitoring of the Earth's environment. A calibration is based on measurements made by Saary and Shorthill by means of scanning an illuminated lunar disk in the visible (0.45 micron) and in the infrared (10-12 micron) wavelengths during a lunation. The intensity scattering of the lunar surface in visible and infrared spectrum is constant and it is not change in space during time. Radiative lunar surface can be easily discribed in the form of analytical dependences, that allow to transform brightness and temperature values to any angle parameters of observation and illumination. Procedure of the calibration is based on the comparison between of signal voltages of the scan image and computer data base, which includes spectrophotometric measurements of the photometric brightness and infrared brightness temperature of a large amount of separate spots on the lunar surface. The image of the Moon in the visible and IR spectrum on the IBM PC screen may be reproduced by an automatic programs. Theoretical brihtness and temperature values were calculated by means of analytical dependences and were compared with numerical values data base. These dependences provide good fit of most of measurements. The analytical fit with brihtness correction is accurate to better than 5%. Measurements of the temperature give of 1.5K in agreement with analytical infrared data.

LUNARSAT MULTIPURPOSE CAMERA

Rainer Riemann (Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany)
Willibald Stumptner (Space Research Institute, Halbärthgasse 1, Graz)
and the Lunarsat team ()

A multi purpose camera system for LUNARSAT, europeans first lunar satellite should be versatile enough to be used for several purposes:
- complete coverage of the moon at high (~10 m) resolution
- photograph selected spots of scientific interest at higher (~1 m) resolution
- multispectral mapping
- stereo imaging
- altimetry

We propose a 1000 mm catadioptric Maksutov Telescope f/10 with 100 mm aperture equipped with a 2-dimensional CCD array. This system has a resolution of 1 m at 100 km distance. In an elliptical orbit the camera could do overall mapping during the apolune phases and photograph selected spots at perilune. Several filters will be used for multispectral mapping. Photographing the same area twice at slighly different angles during the same orbit will provide stereo imaging. An additional laser sharing the telescope optics could be used for LIDAR altimetry, providing topographical information about the shape of the lunar globe, especially of the pemanently shadowed south polar regions.

A MORPHOLOGIC ANALYSIS OF LUNAR SURFACE BASED ON THE MAPS OF CRATER DENSITY, TOPOGRAPHY, BOUGUER ANOMALY AND CRUSTAL THICKNESS

J.F.Rodionova (Sternberg State Astronomical Institute, 119899 Moscow, Russia)
A.M. Berlyant, E.B. Ivanova, O.I.Mastugina (Moscow University, Department of Geography, 119899 Moscow, Russia)

The analysis of features of crater distribution of various classes depending on the degree of rim degradation, morphological types and size over the lunar surface is carried out based on series of 42 colour maps constructed by using the data bank of craters more than 10 km in diameter. The maps visually show a global assymetry in craters distribution over the surface. The maximum of the craters density is typical for the north-eastern part of the far side.The craters density is as twice as low in the southern continental part of the near side. The features of the distribution of craters with central peaks,ridges, hills, terraces, fissures and chains are represented on the maps. The statistic and correlation analysis of crater density as a function of topography, Bouguer anomalies and crustal thickness is carried out and represented on maps of the correlative coefficients. It has been found out that the Moon on the average exhibit an increase in crater density with increasing of the heights. In the near side maria the low crater density corresponds to high mass consentrations At the same time the areas with high crater density to the west from Oceanus Procellarum and to north-west from Marc Moscovience correspond negative values of Bouguer anomalies. Analysis of density lunar craters and crustal thickness show regions were lower crater density corresponds lower thickness (maria regions). higher density corresponds to higher thickness and vice versa. A region to the south west from Vallis Rheita is the only, were higher crater density corresponds to lower crustal thickness.

THE JAPANESE FUTURE LUNAR MISSIONS: LUNAR-A AND SELENE

S.Sasaki, Y.Iijima, H.Mizutani and K.Tsuruda(ISAS, 3-1-1 Yoshinodai, Sagamihara, Kanagawa 229, Japan)

Two lunar missions, LUNAR-A and SELENE, are planned in Japan. The LUNAR-A mission aiming to study the lunar internal structure is to be launched by an M-V launch vehicle in 1997 fiscal year. Three penetrators containing the seismometers and heat flow probes will be deployed from the orbiter and placed on the Moon. The SELENE mission, currently in the stage of phase-A study, is to be developed as the first ISAS/NASDA joint lunar program and be launched by H-IIA rocket in 2003. SELENE will consist of a main orbiting satellite at about 100 km altitude near the polar circular orbit, a relay satellite, and a lander. The orbiter will carry out the global mapping to collect the data on chemical and mineralogical composition, surface and subsurface structure, and remnant magnetic field. The differential VLBI radio sources and the relay satellite will be used to determine the lunar gravity field. The two missions for the lunar interior sounding and global mapping will contribute significantly to better understanding the origin and evolution of the Moon.

A NEW LUNAR PHOTOMETRIC MODEL

Yu.G. Shkuratov, D.G. Stankevich (Kharkov Astronomical Observatory, Sumskaya St., 35, Kharkov, 310022, Ukraine)
A. Dummel, H. Hoffmann, R. Jaumann (DLR, Rudower Chaussee 5, 12489 Berlin-Adlershof, Germany)

The well-known Hapke and Lumme-Bowell photometric models do not take into account two important physical factors: (1) that the coherent backscattering enhancement contributes to the opposition spike; and (2) that the lunar surface relief has a multiscale (fractal-like) structure. We have developed a model that deals with both the shadow-hiding effect and coherent enhancement. We are assuming that the lunar surface can be characterized by three scale ranges. The first range corresponds to stochastic fractal-like relief; it overlaps the scale interval from millimeters to kilometers. The second consists of aggregate particles with sizes from a few microns to millimeters. The third corresponds to small grains of micron-submicron scale which form the larger aggregates. The model uses three basic parameters d, w and W. These are, respectively, d the characteristic slope of relief on the millimeter scale, the single-scattering albedo of grains (w) and the single scattering albedo of aggregate particles (W). Our model includes the leveling down of the opposition spike, which is influenced by the angular dimension of the light source (Sun).

SMALL - A Proposal for a DLR-Lightsat in Lunar Orbit

W. Seboldt, M. Reichert, M. Leipold, M. Klimke, G. Neukum German Aerospace Research Establishment (DLR) Phone: 49-2203-601-3028, Fax: 49-2203-68309, Email: wolfgang.seboldt@dlr.de

SMALL (Small Mission with A Lunar Lightsat) is a low-cost scientific mission to low lunar orbit (LLO) mainly dedicated to remote sensing. It was proposed by DLR in cooperation with Dasa and TU Berlin in 1994 and since then investigated at DLR in a pre-phase A study. The scientific objectives comprise the exploration of the origin and evolution of the Earth-Moon system with global high resolution stereo imaging, spectroscopy and magnetometry - in particular research in lunar mineralogy, chemistry, topography and gravimetry - as well as the identification of future landing sites. The strawman-payload consists of a light-weight stereo (plus super-high resolution) camera, imaging spectrometer, thermal sensor and magnetometer. The mission scenario foresees an Ariane 4/5 piggy-back launch to GTO, lunar transfer and orbit capture with on-board chemical propulsion and a final 100-200 km circular polar LLO. Aiming at a low-cost approach the spacecraft design philosophy requires mostly off-the-shelf hardware, no deployable structures and a short development time. Total mass is less than 250 kg with payload mass of about 30 kg. The main propulsion system consumes monopropellant. The spacecraft is spin stabilized during transfer, three-axes stabilized in LLO with nadir-pointing during imaging mode and Earth-pointing during data transmission with a fixed 1m parabolic dish antenna. Power is provided by body-mounted solar arrays and batteries. The paper contains details of the spacecraft design at subsystem level including mass and power budgets and cost estimates.

LUNAR SOIL MATURITY ESTIMATION BASED ON THE STATISTICAL ANALYSIS OF SPECTRA

D. G. Stankevich; Yu. G. Shkuratov; M. A. Kreslavsky, S. V: Sokolova, N. V. Opanasenko (Kharkov Astronomical Observatory, Sumskaya St, 35, Kharkov, 310022, Ukraine)

As is known, lunar immature soils show more expressive absorption bands in the near infrared and more nonlinear spectrum in the visible range relative to mature soils. To describe this quantitatively, the method of principal components (PC) can be useful. Applied to the spectral catalog of C. Pieters [1], this method reveals that three eigenfunctions is enough to represent the spectral data within the limit of their errors. In the PC coordinates any lunar spectrum is presented as a point in 3D space. All spectra of the catalog form a cloud of points and, if we find the embracing 3D simplex (tetrahedron) with the minimal volume, its apices represent endmembers of the spectral classification. These endmembers correspond to: C(l) - bright craters; B(l) - blue maria; R(l) - red maria; and I(l) - mare regions with strong absorption bands. The last type is characteristic of immature regolith. Thus each lunar spectrum is expressed as a linear combination: F(l) = rR(l) + bB(l) + cC(l) +iI(l), and we can use the coefficient i in this formula as the quantitative measure of regolith immaturity. [1] Pieters C. Lunar spectrophotometric catalogue. Brown Univ. 1990.

LUNARSAT : a proposal for Europe's first lunar orbiter

W. Stumptner*,+ (Space Research Institute, *Austrian Academy of Sciences, Graz, and +Institute for Meteorology and Geophysics University of Graz, Austria), P. Eckart, A. Kalmar, R. Riemann, J.-E. Wahlund and 47 participants of the ESA 1996 Alpbach Summer School from 15 European countries

LUNARSAT is a proposal for a small lunar orbiter, launched before the end of the millenium. This proposal is the answer of the participants of the 1996 ESA Summer School Alpbach "Mission to the Moon" to a challenge of ESA's Director of Science, Roger Bonnet to design, build and launch Europe's first lunar orbiter with a funding of 10 MAU (Million Accounting Units) and a free Ariane piggyback-launch. The proposal for the project by a team of young European scientists and engineers has been presented to ESA for evaluation. The scientific objectives, technical specifications, the proposed team and the current state of the proposal will be discussed.

THE ANALYSIS OF THE INTEGRATION PROCEDURE FOR CONSTRUCTING LONG EPHEMERIDES OF THE MOON

A.A.Trubitsina (Institute of Theoretical Astronomy
Russian Academy of Sciences,
Naberezhnaya Kutuzova 10, St.Petersburg, 191187 Russia,
e-mail 1108@ita.spb.su)

The problem of constructing the long-term numerical ephemeris of the Moon is based essentially on the high-precision numerical integration of the motion of the Sun, major planets, and Moon together with the variational equations of the system. An efficient procedure was elaborated for high accurate integration of ordinary differential equation systems by using the Chebyshev truncated series and a step-size control. An analysis of both an accuracy of the integration procedure and a process of round-off errors accumulation was done with use of supercomuter CONVEX with real*16 floating-point format. It was investigated that the successful solution of the problem of a high-precision long-term numerical integration of the Moon- Earth motion equations demands the choice of convenient parameters for an integration procedure. The optimum strategy for the choice of a step size and an approximation polynomial degree was investigated for the best combination of speed and accuracy for the integration procedure.

GEOLOGIC HISTORY OF THE GRUITHUISEN REGION ON THE MOON, BASED ON CRATER SIZE-FREQUENCY MEASUREMENTS

R. Wagner, U. Wolf, G. Neukum (DLR, Institute of Planetary Exploration, D-12489 Berlin, Rudower Chaussee 5, Germany); J. Head III (Brown University, Providence/RI, USA)

Several volcanic domes associated with mare and highlands are located in the Gruithuisen Region southwest of Iridum crater on the Moon. Based on Lunar Orbiter images, crater size-frequency measurements were carried out in order to derive a sequence of events through geologic time. The following events could be distinguished: (1) The formation of the Gruithuisen volcanic domes (3.8 Ga; 1 Ga = 10^9 years), subsequent to the Imbrium and Iridum impact events. A similar age is found in highlands which very likely were created by the Iridum impact event. (2) Formation of mare materials, with ages of ca. 3.55 Ga. This age is also found in smaller, isolated mare units within highland materials. (3) Extensive mare volcanism (ca. 3.0 Ga). (4) Younger events are probably related to volcanism or mass wasting.

PS6 Planetary magnetospheres and ionospheres

Convener: Prangé, R.
Co-Conveners: Dougherty, M.K.; Sauer, K.

TIME EVOLUTION OF JUPITER'S GLOBAL THERMOSPHERE AND IONOSPHERE

N. Achilleos, S. Miller, D. Rego and J. Tennyson (University College London, UK)

We present time-dependent, three-dimensional model simulations of Jupiter's thermosphere and lower ionosphere (altitudes between 400 and 2000 km above the 1 bar pressure level). Our model numerically solves the equations of momentum and energy transport, auroral energy deposition and appropriate ion-molecule chemistry. To simulate Jupiter's aurorae, we introduce particle precipitation delivering energy into high-latitude oval-shaped regions.
Our simulations cover one rotation cycle of the planet. They reveal auroral energy deposition and ion-neutral collisions as a major source of thermospheric winds. These mechanisms also play major roles in the evolution of the atmosphere near the auroral regions. We make comments about the efficiency of energy transport from auroral to non-auroral regions; and the influence of the magnetic field structure on the morphology of the global (H_3^+) ionosphere.

FINE STRUCTURE OF ELECTROMAGNETIC EMISSIONS IN THE JOVIAN ELECTRON RADIATION BELTS CAUSED BY A EFFECTIVE SATURATION OF ABSORPTION

P.A Bespalov (Institute of Applied Physics, 46 Ulyanov st., 603600 Nizhny Novgorod, Russia)

The properties of the quasilinear interaction of whistler and Alfven waves with the Jovian radiation belts are discussed. It is shown that quasilinear relaxation can lead to an increase of increment of cyclotron instability at the leading front of the electromagnetic pulse. This corresponds to the effective saturation of absorption and makes the deviation of noise emission to the separate electromagnetic pulses energetically advantageous. In self-consistent theoretical analysis it is taken into account that the cold plasma disk is rather thin and the energetic particles in the middle magnetosphere often have butterfly-like pitch angle distribution. Peculiarities of the manifestation of fast and slow (as compared with the pulse length) effective saturation of absorption are discussed. Obtained results are important for exploration of fine structure of electromagnetic radiation in Jovian magnetosphere.

WAVE ACTIVITY IN THE MARTIAN MAGNETOSPHERE

M. Delva (Institut für Weltraumforschung, Österreichische Akademie der Wissenschaften, Inffeldgasse 12, A-8010 Graz, Austria)
E. Dubinin (Max-Planck-Institut für Aeronomie, Postfach 20, 37189 Katlenburg-Lindau, Germany and Space Research Institute, Profsojuznaja 84/32, 117810 Moscow, Russia)

The MAGMA magnetometer FFT data of the Phobos-2 SC from the elliptical orbits around Mars (in February 1989) are investigated for wave activity in the magnetosheath region. They are used as an indicator for pick up ions. The spatial distribution of wave activity is studied, to see if any asymmetries are present. Due to asymmetric pick up processes (higher density in the direction of positive electric field (=North)), a North - South asymmetry in the wave activity should be seen. Also, high wave activity generated by particles related with the bow shock itself is expected. The dependence of wave activity on the distance from the magnetosphere rotational axis is also studied. A systematical decrease of the wave amplitudes with decreasing distance would give an indication of the existence of a cavity void of any plasma.

NUMERICAL SIMULATION OF THE MICROPHYSICS TAKEN PLACE IN THE PLASMA MANTLE OF VENUS

Z. Dóbé (KFKI Research Institute for Particle and Nuclear Physics , Budapest, Hungary)
K. Quest and V.D. Shapiro (Department of Electrical and Computer Engineering, University of California, San Diego, La Jolla)
K. Szegö (KFKI Research Institute for Particle and Nuclear Physics , Budapest, Hungary)

The planetary ionospheres around the non-magnetic planets Mars and Venus are directly exposed to the shocked solar wind. An interaction region between the solar wind protons and the ionospheric oxygen ions takes place in a narrow turbulent regon referred as the plasma mantle. We investigate numerically the non-linear evolution of the modified two-stream instability responsible for VLF electric field activity observed by Pioneer Venus Orbiter. One dimensional electromagnetic hybrid code that retains electron inertia and waves propagating obliquely to the magnetic field have been used in the simulation. While for transversely propagating waves direct coupling of the two ion species through waves is dominant, for oblique case coupling of ions with beat waves (non-linear Landau damping) can also play an important role. Oxygen pick-up and acceleration is found to be dominated by wave effects, resulting in significant ion heating. We also investigated both numerically and analyticaly in the framework of quasi-linear theory the interaction of the electrons with the generated lower hybrid drift instability using test particle approximation.

POTENTIAL CONTRIBUTION OF THE CASSINI MAGNETOMETER TO THE UNDERSTANDING OF THE INTERIORS OF SATURN AND TITAN

M.K.Dougherty, D.J. Southwood, S.J. Kellock and M.W. Dunlop (Blackett Laboratory, Imperial College, London SW7 2BZ, UK)
E.J. Smith (Jet Propulsion Laboratory, Pasadena, CA 91109, USA)

The Cassini spacecraft as an orbiter has an immense advantage over spacecraft flybys as far as planetary field determination is concerned, with a much more complete sampling of latitudes and longitudes being obtained. The magnetometer to be flown on Cassini utilises not only vector helium and fluxgate magnetometers but also has the capability to operate the helium device in a scalar mode. This provides a critical advantage in high magnetic fields by being able to measure the absolute vector field to an accuracy of 1nT anywhere. This will enable the internal field of Saturn to be measured up to the fourth and possibly even the fifth order harmonic terms. Following the recent Galileo flybys of Ganymede it seems certain that Ganymede has an internal magnetic field. Titan and Ganymede are very similar in both size and density, and the possibility cannot be ignored that Titan too might have an internal field. The study of magnetic fields associated with planets and satellites enables us to better understand the interior structure, composition and dynamics of the body.

PLASMA PRESSURES IN COROTATING DISKS

K.M. Ferrière (Observatoire Midi-Pyrénées, 14 av. Belin, Toulouse, France)
M. Blanc (Observatoire Midi-Pyrénées, 14 av. Belin, Toulouse, France)

Giant planet magnetospheres are entrained by the rapid planetary rotation. They contain various plasma components, which are transported outward as a result of interchange motions driven by the centrifugal instability. We investigated how the perpendicular and parallel pressures of each component vary during this outward transport. To this end, we derived evolution equations for the equatorial value of these pressures, based on the assumptions that the magnetic field lines are frozen into the plasma and that the first two adiabatic invariants are conserved. In order to put the resulting equations in a tractable form, we performed a second-order expansion of the magnetic field strength and potential energy along field lines. Finally, we showed how to deduce the pressures at any point along a field line from their equatorial value.
According to our equations, the pressures of outward moving plasma can be modified by a variation in magnetic field strength, by a variation in the effective rigidity of the restoring force responsible for the bounce motion, and by the presence of plasma sources and sinks. In general, our equations deviate from the standard CGL relations, because the bounce motion takes place under the combined action of two distinct restoring forces, the customary magnetic mirror force and the parallel component of the centrifugal force. However, the deviations from CGL approach zero in the limit of a cold plasma component which only feels the centrifugal restoring force, and in the limit of a hot plasma component which only feels the magnetic mirror force.

RESONANT OSCILLATIONS IN THE JOVIAN MAGNETOSPHERE

M. K. Dougherty (Space and Atmospheric Physics Group, Blackett Laboratory, Imperial College, London SW7 2BZ, UK)
N. Krupp (Max-Planck-Institut fuer Aeronomie, D37189 Katlenburg-Lindau, Germany)
A. Lachin and D. J. Southwood (Space and Atmospheric Physics Group, Blackett Laboratory, Imperial College, London SW7 2BZ, UK)

Analysis of both field and particle data from inbound and outbound Ulysses passes at Jupiter in 1992 reveals the presence of periodic signals of around 80 minute period. There is some evidence of higher harmonics (e.g. 40 minute period). We discuss scenarios for generating a resonant structure in the jovian system. We conclude that the field line resonance phenomenon, the basis of such signals at Earth, is unlikely to be the source but rather that the signals represent resonant waves standing in the middle magnetosphere current sheet. We discuss the possible modes of oscillation.

PLASMA AND NEUTRAL COMPOSITION IN THE INNER MAGNETOSPHERE OF SATURN

A. Eviatar (Applied Physics Laboratory, Johns Hopkins University, Laurel MD, USA and Department of Geophysics and Planetary Sciences, The Raymond and Beverly Sackler Faculty of Exact Sciences, Tel Aviv University, Ramat Aviv, Israel)
J.D. Richardson (Center for Space Research, Massachusetts Institute of Technology, Cambridge MA, USA)
V.M. Vasyliūnas (Max-Planck-Institut für Aeronomie, Postfach 20, D-37189 Katlenburg-Lindau, Germany)

Recent HST observations indicate the existence of a large dense cloud of neutral hydroxyl molecules in the inner magnetosphere of Saturn. The inferred neutral densities are large compared to the plasma densities observed by the PLS instrument on board the Voyager spacecraft. This implies that the basic plasma approach for the magnetosphere of Saturn needs revision. We have, therefore, modified our chemical model of the inner magnetosphere. We include as the neutral source the products of dissociative recombination in the ring atmosphere, in the region where the local corotation velocity is large enough to prevent ions from falling into the ionosphere of Saturn but not so large as to impart escape velocity to the products of neutralization reactions. These conditions lead to orbits with apokronia in the region near the orbit of Mimas, *i.e.* near $3R_S$. For reasonable parameters, we find that the HST observations can be reproduced by our model, with the hydroxyl molecules supplied by ion chemistry taking place in or near the Cassini division of the main ring system.

MAGNETIC FIELD LINE DRAPING ABOUT TITAN

P. L. Israelevich (Department of Geophysics and Planetary Sciences, Tel Aviv University, Ramat Aviv, 69978, Tel Aviv, Israel)
F. M. Neubauer (Institute for Geophysics and Meteorology, University of Cologne, Albertus-Magnus-Platz, 50923, Cologne, Germany) and A. I. Ershkovich (Department of Geophysics and Planetary Sciences, Tel Aviv University, Ramat Aviv, 69978, Tel Aviv, Israel)

We consider a correspondence of the magnetic field topology in the Titan wake to an idealized picture of magnetic field lines draping about a conductive non-magnetic obstacle. It is shown that in the inner part of the wake the magnetic field picture differs significantly from that expected for an idealized draping: the transverse magnetic field component rotates by 90° as compared with the direction of the upstream transverse magnetic field. Another difference is the existence of deep magnetic field minima separating the inner and outer parts of the wake. Transverse magnetic field rotation can be explained neither by the upstream magnetic field changes nor by reconnection processes in the wake. These difficulties can be overcome if one assume the existence of a small intrinsic magnetic field of Titan. An effective magnetic dipole of 9×10^{19} G · cm³ can account for the observed topology of the Titan magnetic wake. Another explanation for the observed difference between the inner and outer parts of the wake is the earlier capture of the IMF by the Titan ionosphere (during the periods when Titan was in the solar wind or in the magnetosheath of the Kronian magnetosphere).

SINGLY AND MULTIPLY CHARGED IONS MEASURED UPSTREAM OF THE EARTH'S BOW SHOCK BY THE SMS INSTRUMENT ON WIND

E. Kirsch[1], U. Mall[1], B. Wilken[1], G. Gloeckler[2], A.B. Galvin[2] and K. Cierpka [1]
[1] Max-Planck-Institut für Aeronomie, D-37189 Katlenburg-Lindau, Germany
[2] University of Maryland, College Park, MD 20742, USA

The WIND-S/C performed elliptical orbits around the Earth, flybys on the moon and reached also the libration point L1 in front of the Earth. Singly charged pickup ions and multiply charged solar wind ions as well as energetic ions escaping from the Earth magnetosphere during substorm activity could be measured by the SMS experiment onboard of WIND. The energy, mass and pitch angle measurements are used to discuss the acceleration processes of the particles. The results are then compared with that obtained earlier by the IMP, ISEE and AMPTE satellites which have similar orbits.

ON THE USE OF SPLINE TECHNIQUE FOR SCIENCE DATA VISUALISATION

M. Kolesnik and H. Rosenbauer (Max-Planck Institute fuer Aeronomie, Lindau, Germany.)

The spline technique is a well known method to fit smooth curves on data points. With the advent of computer technology high order spline approximation can be effectively used to improve resolution and build up smooth representation of scientific measurements obtained in space missions. However, spline approximation has also certain limitations, such as preferred directions in the approximant or "difficult features" in the function to be approximated. We applied tensor product spline approximation method to exhibit many dimensional science data measurements in a user friendly way. We use data evaluation technique to calculate and visualise solar wind ion distribution function. These calculations are performed in both radial and three dimensional Cartesian coordinates. The results will be presented and demonstrated using Helios data.

SEPARATION OF DIFFERENT ACCELERATION MODES OF HEAVY IONS IN THE MAGNETOTAIL OF MARS

G. Kotova, M. Verigin, A. Remizov (Space Research Institute, Profsoyuznaya, 84/32, Moscow, 117810, Russia),
W. Riedler, K. Schwingenschuh (Space Research Institute, Infeldgasse 12, A-8010, Graz, Austria)
H. Rosenbauer (Max Planck Institut für Aeronomie, Postfach 20, 37189, Katlenburg-Lindau, FRG)
M. Tatrallyay, K. Szegö (KFKI Research Institute for Particle and Nuclear Physics, 1525 Budapest P.O. Box 49, Hungary

On the basis of the plasma and magnetic field data obtained on board the Phobos 2 spacecraft, different acceleration processes of heavy ions in the Martian magnetotail are discussed. As it was shown earlier the solar wind ram pressure determines whether the Martian magnetosphere is mostly induced or the intrinsic magnetic field of Mars is the most important factor for its formation. The significance of different acceleration processes of heavy ions is examined for the above mentioned two cases. The dependence of heavy ion energy on the ion mass is discussed in relation with the possible acceleration processes.

FLOW VELOCITIES IN THE JOVIAN MAGNETOSPHERE. COMPARISON OF RESULTS FROM THE ULYSSES-EPAC AND THE GALILEO-EPD PARTICLE INSTRUMENTS

N. Krupp (Max-Planck-Institut für Aeronomie, D-37189, Katlenburg-Lindau, Germany)
A. Lagg, E. Keppler, B. Wilken, S. Livi, J. Woch, R. Seidel (all at: Max-Planck-Institut für Aeronomie, D-37189, Katlenburg-Lindau, Germany)
D.J. Williams, E.C. Roelof, B.H. Mauk (all at: The Johns Hopkins University, Applied Physics Laboratory)
M.K. Dougherty (Blackett Laboratory, Imperial College, London)

Whereas ULYSSES only flew through the Jovian magnetosphere once entering on the morning side around 10:00 local time (LT) and exiting towards southern latitudes along the 18:00 LT meridian, GALILEO is the first orbiting spacecraft in the Jovian system providing measurements from all system III longitudes at different radial distances from the planet. We present calculated flow velocities of different energetic ions in the energy range E > 50 keV using 3-dimensional first-order anisotropies obtained inside the Jovian magnetosphere from the EPAC instrument aboard ULYSSES and the EPD experiment aboard GALILEO. Both instruments provide: (i) up to 16-direction spatial resolution covering the full unit sphere; (ii) composition measurements of clearly separated ion species; and (iii) spectrum measurements from 3-8 differential energy channels. We use a 3-dimensional spherical harmonic analysis of the intensity anisotropies and compare the flow velocities calculated in different regimes of the Jovian magnetosphere.

FLOW VELOCITIES INSIDE THE JOVIAN MAGNETOSPHERE: RESULTS OF THE ENERGETIC PARTICLES DETECTOR (EPD) ABOARD GALILEO

N. Krupp (Max-Planck-Institut fuer Aeronomie, D-37189, Katlenburg-Lindau, Germany)
A. Lagg, B. Wilken, S. Livi (All at: Max-Planck-Institut fuer Aeronomie, D-37189, Katlenburg-Lindau, Germany)
D. J. Williams, E.C. Roelof, R.W. McEntire, B. H. Mauk, S. M. Krimigis (All at: The Johns Hopkins University, Applied Physics Laboratory)
T.P. Armstrong (The Department of Physics and Astronomy, The University of Kansas)
L.J. Lanzerotti (Bell Laboratories, Lucent Technologies)
T.A. Fritz (Center of Space Physics, Boston University)
J.G. Roederer (Geophysical Institute, University of Alaska)

We report on energetic particle measurements from the Energetic Particles Detector (EPD) aboard the Galileo spacecraft inside the Jovian magnetosphere. The measurements for this study were taken predominantly in the predawn magnetotail of Jupiter's magnetosphere at distances between 15 and 120 RJ. Flow velocities of ions are derived from three-dimensional first order anisotropies assuming that intensity gradients do not play a significant role. We find velocities less than rigid corotation far away from the center of the equatorial plasma sheet. Inside the plasma sheet the ions rotate approximately with the rigid corotation velocity in the dawn sector, but in the midnight-predawn sector the derived flow velocities are significantly less than rigid corotation.

DEPLETION OF ENERGETIC SULFUR IONS AT HIGH PITCH ANGLES OBSERVED FROM THE ENERGETIC PARTICLES DETECTOR (EPD) ON BOARD THE GALILEO SPACECRAFT IN THE IO PLASMA TORUS

A. Lagg (Max-Planck-Institut fuer Aeronomie, D-37189, Katlenburg-Lindau, Germany)
N. Krupp, B. Wilken, S. Livi ((All at: Max-Planck-Institut fuer Aeronomie, D-37189, Katlenburg-Lindau, Germany)
D. J. Williams, E. C. Roelof, R. W. McEntire, B. H. Mauk, S. M. Krimigis (All at: The Johns Hopkins University, Applied Physics Laboratory)
T. P. Armstrong (The Department of Physics and Astronomy, The University of Kansas)
L. J. Lanzerotti (Bell Laboratories, Lucent Technologies)
T. A. Fritz (Center of Space Physics, Boston University)
J. G. Roederer (Geophysical Institute, University of Alaska)

Results from the Energetic Particles Detector (EPD) on board the Galileo spacecraft during its pass through the Io plasma torus in December 1995 are presented. For about 20 minutes at a distance of several Io radii before closest approach to Io the detect or measured the first quasi 3-dimensional particle distributions in the energy range from 15 keV to several MeV. The data show a strong depletion of energetic sulfur ions at 90 degrees pitch angle and a more isotropic distribution for oxygen ions. We prop ose an explanation for the pitch angle distributions observed considering especially the process of charge exchange between energetic ions and neutrals in the Io plasma torus

OBSERVATIONS OF VARIATIONS OF EUV EMISSION LINES IN THE IO PLASMA TORUS

G. Lichtenberg and N. Thomas (Max–Planck–Institut für Aeronomie, Postfach 20,D–37189 Katlenburg–Lindau, GERMANY)

Since the discovery of the Io Plasma Torus (IPT) around Jupiter several papers dealt with the variability of emission lines in the optical range. But since most of the energy of the IPT is radiated in the extreme ultraviolet, these works give only an incomplete picture of the physical processes in the torus. For example it is not clear if the energy necessary to maintain the radiative losses from the IPT can be provided only by pick–up of ions by the rotating magnetic field of Jupiter. If this is not the case, then one possibility to balance the energy is an additional electron energy source. Model calculations by Schneider et al. (1996) predict an *absence* of variations in the EUV in the presence of an electron energy source. The observations analyzed here gives us the possibility to address this question. They were performed by the EUVE satellite in the wavelength range from 280Å to 760Å in 1994 and 1995. The instrument provides imaging information and each photon event is time tagged. Thus it is possible to investigate variations of emission lines in System III and decide if an additional electron energy source exists. Furthermore the EUV provide a better way than optical emissions to look at variations in the electron temperature, which in turn can set constraints on model calculations of the IPT. We present the results of our preliminary investigations.

References: Schneider et al., On the nature of the brightness asymmetry in the Io torus, *JGR* 1996, submitted.

SOLAR WIND ABSORPTION NEAR MARS

H. Lichtenegger (Institut für Weltraumforschung, Österreichische Akademie der Wissenschaften, Inffeldgasse 12, A-8010 Graz, Austria)
E. Dubinin (Max-Planck-Institut für Aeronomie, Postfach 20, 37189 Katlenburg-Lindau, Germany and Space Research Institute, Profsojuznaja 84/32, 117810 Moscow, Russia)

Based on recent models of the martian exosphere, the solar wind absorption due to charge exchange with various constituents of the dayside upper neutral atmosphere is evaluated. It is found that the absorption is maximal for the atmospheric models corresponding to solar minimum conditions, while those for solar maximum yield values of about 1/5 of the maximum absorption. The effect of the solar wind absorption on the bow shock position is also studied and escape rates of newly born ions, originating from the neutral atmosphere, as well as their total fluxes are estimated.

CORIOLIS EFFECTS ON THE COUPLING OF COMPRESSIONAL MHD MODES TO FIELD LINE RESONANCES IN THE JOVIAN MAGNETOSPHERE.

C.F.A. Lofting, M.K. Dougherty and D.J. Southwood

Space and Atmospheric Physics, Blackett Laboratory, Imperial College London, London SW7 2AZ.

The work to be presented examines the effects of rotational motion on the coupling between compressional and purely transverse MHD signals (known as field line resonances). A straight field configuration is modelled for a constantly corotating magnetosphere and simple coupling is achieved by introducing a density gradient in the radial direction. The Coriolis force is shown to dominate the rotational dynamics of ULF MHD modes in the Jovian magnetosphere and analysis is carried out on how it effects resonance conditions to first and second order in Ω_J (the rotational frequency of Jupiter). It is shown that whereas to first order the effect is limited to shifting the locations where the solutions oscillate, grow or evanesce, the inclusion of terms to second order can affect the resonance locations.

GALILEO OBSERVATIONS AT IO: AN ANALYSIS OF THE MORPHOLOGY OF THE IO PLASMA ENVIRONMENT

P.Louarn (Observatoire Midi-Pyrénées, Toulouse, France)
S. Perraut and A. Roux (Centre d'Etude des Environnements Terrestres et Planétaires, Vélizy, France)
S. Bolton (Jet Propulsion Laboratory, Pasadena, USA)
W. Kurth and D. Gurnett (University of Iowa, Iowa, USA)

During its insertion orbit, Galileo has crossed the Io wake at low altitudes (less than 1000 km) from the planet. This was an unic and precious occasion for analysing the interaction between the most volcanic body of the solar system and Jupiter.
Taking advantage from the observations of two radio occultation events and from the local measurements of the density, we show that Io has a very specific plasma environment. The main surprise is the existence of a thin slice of dense plasma ($n > 5\ 10^4\ cm^{-3}$), at the center of the wake, that extends far from Io (at least 1000 km). Conversely, no dense plasma region has been detected over the leading edge of Io. This strong assymetry must likely be related to the Io interaction with the magnetospheric plasma. The origin of the plasma structure and its modelisation are two largely open problems.

MODELLING DISTANT PLANETARY MAGNETOSPHERES

Wiesław M. Macek (Space Research Centre, Polish Academy of Sciences, Bartycka 18 A, 00-716 Warszawa, Poland)

We assume that the distant planetary magnetotails of Earth, Jupiter, Saturn, Uranus, and Neptune are partially open, long plasma cavities in pressure equilibrium with the solar wind. We use the Voyager, Ulysses and Galileo (for Jupiter) observations to initialise our calculations in the near-planet portion of the magnetotail. We present information on estimates of magnetotail cross-sections, magnetic field strengths, and plasma densities as a function of downstream distance. Comparison of our results for Earth with the ISEE 3 and Geotail and for Jupiter with the Voyager 2 observations suggests that our model accurately describes the gross features of the distant planetary magnetotails of the Earth and also of all outer magnetic planets.

REMOTE SENSING OF THE FUV JOVIAN AURORAE DURING IN-SITU GALILEO MEASUREMENTS

R. Prangé (IAS, Bat. 121, Université Paris-XI, Orsay Cedex, France)
L. Frank (University of Iowa, Iowa City, USA)
M. Kivelson (UCLA, Los Angeles, USA)
D. Rego and S. Miller (UCL, London, UK)
P. Zarka (DESPA, Observatoire de Meudon, France)
D. Southwood (Imperial College, UK)
P. Louarn (OMP, Toulouse, France)

High latitude particle precipitation from the magnetosphere causes collisional excitation of atmospheric H and H_2, and gives rise to FUV auroral emissions. The auroral pattern is the 2-D projection of active regions in the magnetosphere along magnetic field lines. By contrast, the spectral characteristics of the emission bear the signature of the precipitating particles and of the auroral atmospheric structure.
High spatial resolution images of the FUV Jovian aurorae in the H_2 Lyman bands, and spatially resolved Lyman α and H_2 band spectra have been taken with the HST Faint Object Camera and Goddard High Resolution Spectrograph in coordination with Galileo particle and field measurements in the dayside magnetosphere. The remote sensing data can also be compared with similar observations made in 1994. Finally, the global auroral activity of Jupiter has been regularly monitored during the long Galileo survey of August-September 1996 with IUE, allowing to compare the aurora and magnetosphere characteristic timescales.

THE SPATIAL DISTRIBUTION OF H_3^+ EMISSION ON JUPITER: A NEW HIGH SPATIAL RESOLUTION STUDY.

D. Rego and S. Miller, N. Achilleos, H.A. Lam (Dept. of Physics and Astronomy, UCL Gower Street, London WC1E 6BT, UK)
R.D. Joseph (Institute for Astronomy, University of Hawaii, USA)

RECENT infrared studies of the global emission of the H_3^+ molecular ion from Jupiter have shown that this species makes an important contribution to the overall energy balance of the jovian ionosphere. In the auroral regions, H_3^+ emissions are comparable in energy output to those reported for ultraviolet aurorae. In the mid-to-low latitude regions, H_3^+ emission is similar in intensity to the Lyman-α glow. The infrared studies have also shown that the spatial variation of H_3^+ emission may be a useful tool for investigating the magnetic field of Jupiter.
We report on a series of new observations made using the Nasa IRTF facility spectrometer, CSHELL, which show the latitudinal variation of H_3^+ emission in unprecedented spatial detail. These data will be used to probe the detailed nature of the jovian magnetic field in the peri-auroral regions and in the mid-to-low latitudes.

FURTHER RESULTS FROM ULYSSES JUPITER FLYBY: MEASUREMENTS OF ENERGETIC H_3^+-MOLECULES MADE BY THE EPAC INSTRUMENT

R. Seidel (Max-Planck-Institut für Aeronomie, D-37191 Katlenburg-Lindau, Germany)
E. Keppler, N. Krupp, J. Woch (All at: Max-Planck-Institut für Aeronomie, 37191 Katlenburg-Lindau, Germany)

The abundance of energetic H_3^+-molecules in the Jovian magnetosphere which was already reported by the LECP instrument on Voyager and by the HI-SCALE instrument on Ulysses had recently been confirmed by the EPAC instrument, which is also onboard the Ulysses space probe. EPAC with its four identical telescopes provides the opportunity to investigate the three dimensional flux direction of these H_3^+-molecules which are known to originate on Jupiter. An attempt will be made to determine the origin of energetic particle fluxes in and near to the Jovian magnetosphere.

THE PLASMA DISTRIBUTION IN THE IO TORUS.

N. Thomas and G. Lichtenberg (Max-Planck-Institut fuer Aeronomie, D-37191 Katlenburg-Lindau, Germany)

Measurements of ion temperature (T_i) in the Io plasma torus (IPT) have shown considerable disagreement. On the one hand, Voyager PLS observations have indicated that T_i rises with Jovicentric distance. This is counter-intuitive because T_i should decrease with Jovicentric distance as the plasma expands outwards into the middle magnetosphere. Various heating mechanisms have been invoked to explain this behaviour. On the other hand, Voyager UVS data and ground-based measurements of T_i on the plasma equator show the expected decrease with Jovicentric distance and similar adiabats (roughly $L^{-8/3}$) have been fitted to the temperature distributions.
We report additional ground-based measurements of T_i with magnetic latitude. These observations show a clear increase in temperature with increasing height above the plasma equator. This is a clear indication of a non-Maxwellian distribution. Parameters derived from fitting the temperature with a Kappa distribution have been used to determine whether PLS T_i measurements can be reconciled with decreasing temperatures along the plasma equator if the latitude of the spacecraft is taken into account. It is shown that the different measurements can indeed be reconciled. However, the results imply that previous extrapolations of the ion densities and temperatures to produce 2-D distributions of the plasma distribution in the IPT are in considerable error.

BOW SHOCK AND MAGNETOSHEATH STRUCTURING DUE TO MASSLOADING AT WEAK COMETS AND MARS

Konrad Sauer, Eduard Dubinin (Max-Planck-Institut für Aeronomie, 37191 Katlenburg-Lindau, Germany)
Klaus Baumgärtel (Astrophysikalisches Institut Potsdam, OSRA, 14473 Potsdam, Germany)

Measurements in the plasma environment of Mars and comets Giacobini-Zinner and Grigg-Skjellerup have shown that the structure of the bow shock is significantly influenced by the pick-up of heavy ions. An additional characteristic feature is the appearance of bi-ion plasma boundaries within the magnetosheath, which are caused by the interaction of the shocked solar wind with the heavy ion flow. Comparative data analysis is made and the observed effects are discussed by means of bi-ion fluid modelling.

LOW FREQUENCY TURBULENCE NEAR PROTON GYROFREQUENCY IN THE MARTIAN FORESHOCK.

V. Tarasov (Lviv Centre of the Ukrainian Space Research Institute, Naukova 5a, Lviv, Ukraine)
E. Dubinin and A.Skalsky (Space Research Institut, ul.Profsoyusnaya 84132, 117810, Moscou, Russia)
S. Perraut (CETP-IPSL, 10-12 av. de l'Europe, FR-78140 Velizy, France)

Using magnetic field measurements, carried out by MAGMA magnetometer onboard the PHOBOS, we have studied the fine structure of the magnetic field turbulence in the Martian foreshock. With the help of wavelet transform we analysed the power of magnetic field fluctuation and revealed presence of the short wave pakets with the frequencies near and below proton gyrofrequency. In order to understand the source of this turbulence, we have compared the traces of the sum the wavelets coefficients in certain frequency bands with the particle data of ASPERA and assymetry model of the Mars and solar wind interaction. Comparison shows good correlation between power of fluctuation near the proton gyrofrequecy and number of backstreaming ions. Wave packets with the frequencies below proton gyrofrequency were identified as biion frequency, due to presence of the oxygen pick-up ions.

GEOMETRY OF THE PLASMA SHEET IN THE MIDNIGHT-TO-DAWN SECTOR OF THE JOVIAN MAGNETOSPHERE: PLASMA OBSERVATIONS WITH THE GALILEO SPACECRAFT

V.M. Vasyliūnas (Max-Planck-Institut für Aeronomie, Postfach 20, D-37189 Katlenburg-Lindau, Germany)
L.A.Frank, K.L.Ackerson, and W.R.Paterson (Department of Physics and Astronomy, University of Iowa, Iowa City, Iowa 52242, U.S.A.)

From August 10 to October 22, 1996, the Galileo spacecraft made observations in the midnight-to-dawn sector of the magnetosphere of Jupiter out to a distance of $120R_J$, encompasing the region previously explored by the outbound passes of the Pioneer 10, Voyager 1, and Voyager 2 spacecraft. We use the count rates of electrons with energy between 1 and 4 keV, measured by the PLS experiment, to identify the plasma sheet and to study its configuration. The observations are consistent with the generally accepted picture of a thin plasma sheet in the magnetic equatorial region, which propagates outward as a surface wave generated by the rotation of the tilted magnetic dipole of Jupiter. A new result, made possible by the long duration of the Galileo observations, is that the observed rotational variation of the count rates is subject to a longer-term, $\approx$ 5-7 day modulation, indicating changes in the mean location, or the surface-wave amplitude, or the thickness of the plasma sheet, or a combination of these. The cause of this modulation has not been yet definitively identified. Solar wind effects, dynamics of plasma supply from the Io torus to the plasma sheet, and drifting longitudinal asymmetry of the hinging distance for the plasma-sheet surface wave are among the possibilities.

PLANETARY BOW SHOCK MODEL APPLICABLE FOR A WIDE RANGE OF UPSTREAM MACH NUMBERS AND DIFFERENT SHAPES OF THE OBSTACLE

M.Verigin, A.Remizov, G.Kotova, (Space Research Institute, Profsoyuznaya, 84/32, Moscow, 117810, Russia),
H.Rosenbauer (Max Planck Institut für Aeronomie, Postfach 20, 37189, Katlenburg-Lindau, FRG)
W.Riedler, K.Schwingenschuh (Space Research Institute, Infeldgasse 12, A-8010, Graz, Austria)
K. Szegö, M. Tatrallyay (KFKI Research Institute for Particle and Nuclear Physics, P.O. Box 49, 1525 Budapest, Hungary)

An analytical empirical bow shock model is presented as a function of M_a Alfvenic and M_s sonic Mach numbers, and of the angle between the subsolar shock normal and the upstream magnetic field. Range of the model applicability is $1 < M_s < \infty$ (in hydrodynamic approximation). The model can be applied, e.g., for the explanation of the unusually weak dependence of the Martian terminator bow shock position on the solar wind ram pressure according to Phobos 2 data, and for the quantitative description of unusually distant shocks observed at Venus by PVO. Limitations of the model's applicability in MHD approximation are discussed also.

SOLAR WIND CONTROL OF THE VENUS BOW SHOCK

T. L. Zhang (Space Research Institute, Graz, Austria)
K. K. Khurana and C. T. Russell (IGPP, UCLA, Los, Angeles, U.S.A.)
K. Schwingenschuh and W. Riedler (Space Research Institute, Graz, Austria)

Pioneer Venus observations show that the position of the Venus bow shock varies with the solar cycle, the solar wind Mach number and the IMF orientaiton. Day-to-day variablity in the shock size occurs principally due to Mach number fluctuations in the solar wind while over the course of the solar cycle these average out. The solar cycle variation of the bow shock location is due principally to the changes in EUV flux presumably due to its effect on mass loading by pickup ions. Recently, Khurana and Kivelson (1994) have proposed a variable cross-section bow shock model. In this paper, we compare this bow shock model with our PVO observations.

LABORATORY SIMULATION OF MAGNETOPAUSE DYNAMICS AND RELATED PLASMA PENETRATION PROCESSES CAUSED BY STRONG SOLAR WIND DISTURBANCES. *

Yu.P. Zakharov (Institute of Laser Physics, Russian Academy of Sciences, Pr. Lavrentyeva 13/3, 630090, Novosibirsk, Russia; E-mail: pon@dlp.nsk su)

We consider following to proposal of Ponomarenko and Soloukhin (1976) the possibility of simulation a global and non-stationary magnetospheric phenomena in laser-produced plasma experiments with dipole (up to 10 MG*cm3, flowing by 10^{13} - 10^{14}/cc background plasma) in a large-scale chamber (diam. 1.2*5m) of KI-1 facility, supplied by CO2-lasers of kJ-range. Such experiments will help to understand and to predict the geoeffectiveness of impact of natural disturbances in solar wind as well as an after-effects of artificial plasma releases in near-Earth space (active experiments, anti-asteroidal explosions) and finally to investigate the basic physics of magnetosphere formation or stability under various ionospheric conditions. The main goal of the first experiments is to study the various mechanisms of solar wind (SW) plasma invasion through magnetopause due to direct impulsive penetration of SW irregularities (Lemaire,1977) or due to local (Book and Sibeck, 1995) as well as to the global (Gratton et al,1996) Rayleigh-Taylor instability of magnetopause. All this processes are realized by Laser-Produced Plasma (LPP) ejection at various stand off distances from magnetopause (Zakharov et al, 1996) and for the first time under laboratory conditions of high-level ion magnetization of LPP and "SW plasma". Preliminary data about "artificial magnetosphere"' formation and instability in LPP' flow are presented.
* Work is supported by Russian Fund of Basic Research.

PS7 Small bodies of the solar system

Convener: Schwehm, G.H.
Co-Convener: Ulamec, S.

Period and pole determinaton of asteroids

C. Blanco, D. Riccioli

Astronomy Institute of Catania University, V.le A. Doria, 6 - 95125 Catania, Italy

By means of B and V photoelectric observations, carried out at M.G. Fracastoro station of Catania Astrophysical Observatory, the lightcurves of 34 Circe, 97 Kloto, 176 Iduna and 313 Chaldea were obtained.
By adding to the data existing in the literature our new observations, we obtained the lightcurve minimum number necessary to apply the pole computation methods to 14 asteroids.
We present the value of the rotation axis orientation and of the axes ratio, relative to these objects.

A SPECTRAL EVIDENCE OF A COMMON ORIGIN OF 75 EURYDIKE AND 201 PENELOPE?

V.V. Busarev (Sternberg State Astron Inst., Moscow 119899, RUSSIA)

The main belt M asteroids 75 Eurydike and 201 Penelope have some very close orbital elements (semi-major axes, inclinations, mean anomalies) [1]. This may show a common origin of the bodies from a parental planetesimal. At the same time reflectance spectra of the asteroids obtained at small phase angles contain similar absorption features also. The first is near 510nm with a width of about 250nm and intensity of 1-8% on Eurydike and with 300nm-width and 1-5%-intensity on Penelope. The second is at 630nm with a width of 300nm and intensity of 5-6% on Eurydike and with almost 600nm-width and 2-15%-intensity on Penelope (it could be there as a superposition of two ones at 600 and 650nm). The spectral features are present on the all reflectance spectra but have different shapes and intensities depending on the phases of rotation. The parameters of the spectral features correspond probably to those of pyroxenes and their oxidized varieties including Cr-pyroxenes [2-4]. A possible confirmation of such mineralogy is a specific absorption band on the spectra of Penelope at 430nm. A somewhat different interpretation of the spectral features could allow a presence on surfaces of the bodies (or at least on Penelope) of some quantity of clays [5, 6].

COMETARY DYNAMICS DURING THE FORMATION OF THE PLANETARY SYSTEM

S. Eggers (Max-Planck-Institut für Aeronomie, Postfach 20, D-37189 Katlenburg-Lindau, Germany)

We investigate the dynamical fate of the solar system's comet population if the sun formed in an embedded star cluster. In particular, numerical integrations of perturbations by cluster stars on comets in the sun's postulated extended protoplanetary disk (out to several hundred AU) are presented. Because of the higher stellar number density and the lower relative velocity between the stars in the cluster, such perturbations would be more numerous and individually more severe than perturbations in the sun's present environment. Preliminary Monte Carlo simulations of the cumulative effect of all stars indicate that strong perturbations can occur. Because these took place at an early stage in the history of the solar system, they might not only have affected readily-formed comets, but also disturbed pre-cometary objects in the process of accumulation.

SIMULATION OF COMET HYAKUTAKE'S X-RAY EMISSION WITH A MULTISCALE 3D MHD MODEL

T.I. Gombosi, R.M Häberli, D.L. DeZeeuw and K.G. Powell (The University of Michigan, Ann Arbor, USA)
T.E. Cravens (The University of Kansas, Lawrence, USA)

Cravens [1997] explained the strong emission of X-rays by comet Hyakutake with high charge state solar wind ions (O^{6+}, O^{7+}, C^{4+}, C^{5+}, Ne^{8+}) undergoing charge exchange with cometary molecules or atoms. In most cases the electron capture will proceed into a highly excited state of the solar wind ion which will subsequently decay into the ionic ground state by emiting EUV radiation and X-rays. *Cravens* [1997] estimated this process to account for the slowly varying X-ray intensity observed by the HRI and the WFC on ROSAT [*Lisse et al.*, 1996] within a factor of two. We have computed the three dimensional solar wind flow in the coma of comet Hyakutake with our multiscale MHD-model of cometary plasma environments [Gombosi et al. 1996]. The effects of mass loading, recombination and ion-neutral friction are taken into account by the governing equations, which are solved using a shock-capturing numerical technique. This method is applied on an adaptively refined unstructured grid. We integrated the continuity equations for the major high charge state ions in the solar wind along the computed stream-lines, taking into account charge transfer with cometary gas. From this we compute the volume emission rate of X-rays and EUV radiation. By integrating along the line-of-sight we obtain isophotes of the expected absolute X-ray luminosity which we will show in comparison with the ROSAT measurements.

CCD polarimetric imaging of comet C/1995 O1 (Hale-Bopp). Comparison with other comets

E. Hadamcik (Université Paris 6/Service d'Aéronomie, BP3, 91371, Verrières, France)
J.B. Renard (LPCE/CNRS, Orléans, France)
A.C. Levasseur-Regourd (Université Paris 6/Serv. d'Aéronomie, France)

The solar light scattered by dust particles in comets has been observed by CCD polarimetry at Pic du Midi Observatory (France) since 1990. This technique of observation allows to enhance structures that are not easily visible in brightness maps.
We present images of comet C/1995 O1 (Hale-Bopp) observed in 1996 at 19° and 7° phase angles. The polarization maps will be compared with those of comets C/1990 C1 (Levy), 47P (Ashbrook-Jackson) and 22P (Kopff). This comparison allows:
-to study the evolution of the polarization in the different parts of the coma as function of phase angle and heliocentric distance.
-to enlarge our knowledge of the physical properties of the dust particles
-to try to specify if the large polarization values in the jets are resulting from submicronic grains oriented by the gaz drag or from large fluffy particles.

SUBMILLIMETER OBSERVATIONS OF HALE-BOPP USING A HIGH RESOLUTION CHIRP TRANSFORM SPECTROMETER

P. Hartogh and C. Jarchow (Max-Planck-Institut für Aeronomie, Postfach 20, D-37189 Katlenburg-Lindau, Germany)
S. Gulkis and M. Hofstadter (Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, USA)
R. Martin and J. McMullin (Steward Observatory, University of Arizona, Tucson, AZ 85721, USA)

In preparation of the ROSETTA-MIRO project, a breadboard model of a Chirp Transform Spectrometer (CTS) has been developed. Similar spectrometers have been successfully used for long term sounding of the Earth atmosphere, however there has been no proof so far that the CTS is a suitable instrument for radioastronomical observations. Therefore the CTS has been embedded in a submillimeter measurement campaign of Comet Hale-Bopp, using the new Heinrich-Hertz-Telecope on Mt. Graham in Arizona, USA. The first part of the campaign took place in November 1996 and supplied superior data of the 345 GHz and the 461 GHz CO transitions, which have been used to determine the production rate. The measurement of composition, velocity and temperature in the coma of Hale-Bopp are planned for part 2 of the campaign, which will take place in March/April 1997. The experiment will be described and results of part 1 as well as part 2 of the campaign will be presented.

Model Calculations of the Solar Dust Corona

P.Hillebrand, I.Mann, H.Kimura (Max-Planck-Institut für Aeronomie, Postfach 20, D-37189 Katlenburg-Lindau, Germany)

The spatial distribution and the scattering and thermal properties of the interplanetary dust near the Sun is studied by inversion of the F-coronal brightness. We discuss the results of the observations of the solar corona in the visible and near infrared wavelength and compare them with models for the spatial distribution out of the ecliptic derived from the visible and near infrared brightness of the Zodiacal light. Furthermore we present an analysis of the observations in respect to the scattering and thermal properties.

DUSTY GAS FLOW NEAR THE NUCLEUS OF COMET WIRTANEN: FIRST RESULTS OF A 3D AMR MODEL

K.S. Kabin, T.I. Gombosi, D.L. DeZeeuw and K.G. Powell (The University of Michigan, Ann Arbor, USA)

The first results of a new 3D dusty gasdynamic model of near nucleus flows are presented. The dust-gas momentum and energy exchange is treated on the basis of free-molecular theory. Coupled equations of gas and dust dynamics are solved using a second order Godunov-type method on a solution-adaptive multiscale grid. Any number of dust sizes can be handled. Stiffness due to the grid properties is removed by local time stepping and stiffness arising from the gas-dust momentum exchange terms is reduced through point-implicit implementation of the source terms. Several cases of flows around the nucleus of comet Wirtanen are investigated with different gas/dust production ratios, dust sizes and nucleus characteristics.

THE GEMINIDS STREAM STRUCTURE

M.V. Kazakov, A.V. Karpov, A.M. Stepanov (Kazan State University, Kremlevskaya st, 18 Kazan 420008, Russia)

In the process of the meteor stream evolution there is a change of the spatial structure distribution of particles along to their trajectories. It is suggested the original statistical method to determine structure of meteor streams based on handling of the radar observation results. The characteristics of particles grouppings is determined for the data obtained from radar observation of the Geminids meteor flux passed in 1983 and 1988. On periphery of stream (Dec, 10-13) the part of groupping particles forms 10-15%. The grouppings have length of 16000-20000 km. The part of groupping particles on Dec, 14 reaches 30-45%. The most part of grouppings has length more than 9000 km. The part of grouppings on Dec, 15 decreases until 25-35%. The most part of grouppings has size up to 7000 km.

THE DYNAMICS OF COSMIC DUST NEAR THE SUN UNDER THE INFLUENCE OF RADIATION PRESSURE AND LORENTZ FORCE

H. Kimura and I. Mann (Max-Planck-Institut für Aeronomie, Katlenburg-Lindau, Germany)
A. V. Krivov (Astronomical Institute, St. Petersburg University, Russia)

The orbital evolution of charged dust particles in interplanetary space is affected by the radiation pressure force and the Lorentz force due to the solar magnetic field, as well as by the gravitational force of the Sun. These forces acting on particles increase with approaching the Sun and can eject particles in hyperbolic orbits. In order to estimate the amount of particles that are ejected from the solar environment, we use model calculations of the radiation pressure force. On the other hand, it is necessary to obtain the charge of dust particles in order to derive the Lorentz force. We calculate the charges, taking into account the sticking and penetration of solar wind particles into dust grains, the secondary electron emission due to the plasma particles, and the photoelectron emission. In addition, we discuss the influence of the material composition and solar wind phase on the charging of dust grains. Besides, the dust particles suffer from sublimation near the Sun. The sublimation changes the ratio of the radiation pressure and Lorentz forces to the solar gravitational force. On the basis of the numerical calculations described above, we estimate the local number density of dust particles near the Sun and its temporal variations with the solar activity cycle.

PHASE POLARIZATION DEPENDENCE OF DUSTY COMETS AFTER POLARIMETRIC OBSERVATIONS OF COMETS C/1996 B2 (HYAKUTAKE) AND C/1995 O1 (HALE – BOPP)

N. N. Kiselev (Astron. Obs. of Kharkov State University, Sumskaya str. 35, Kharkov 310022, Ukraine)

Polarimetric and photometric observations of the comets C/1996 B2 (Hyakutake) and C/1995 O1 (Hale–Bopp) are presented. The observations were conducted at the 70-cm telescope of Kharkov University Observatory. The phase angles of Hyakutake and Hale–Bopp changed in the ranges 57.7 – 111.1° and 4.8 – 13.0°, respectively. The comet Hyakutake and comet Hale–Bopp belong to the group of dusty comets by their polarimetric as well as colorimetric properties of dust particles. The position of the polarization maximum (P_{max} and α_{max}) of the comet Hyakutake is found to be 24 %, 93.6° and 26.5 %, 93.6° in blue and red domains of continuum, respectively. The polarization degree of the comet Hale–Bopp is in a good agreement with the data for the comet P/Halley at the same phase angles. The synthetic polarization phase dependence of dusty comets in the range of phase angles 0 – 111° is discussed.

SIZE DISTRIBUTION OF COMETARY DUST AT DIFFERENT DISTANCES FROM THE NUCLEUS

L.O. Kolokolova, K. Jockers (Max-Planck-Institut für Aeronomie, Katlenburg-Lindau, Germany)
A. Kogan (Technion, Haifa, Israel)

We offer a model of motion of cometary dust particles at distances up to 10^5 km from the nucleus. The model includes the acceleration by aerodynamic drag close to the nucleus and by solar light pressure outside the innermost region. The size distribution of cometary dust at different distances from the nucleus is studied in relation to the particle properties (complex refractive index, density of their material, near-nucleus size distribution) and some environmental parameters (nucleus size, heliocentric distance, sound speed in cometary gas). The model is applied to the data of *in situ* measurements collected within the Halley coma at a range of cometocentric distances by the experiment SP-2 on board the Vega spacecraft. The properties of the dust consistent with the *in situ* measurements are determined.

ON THE NATURE OF SOFT X-RAY RADIATION IN COMETS

V. A. Krasnopolsky (NRC/NASA/Goddard Space Fight Center, Greenbelt)

EUVE and ROSAT observations of comet Hyakutake revealed emission of 7×10^{24} ph/s in the soft X-ray. We discuss and develop methods to calculate production of soft X-ray photons in cometary dust and gas by: (1) scattering and (2) fluorescence of solar X-rays; (3) K- and L-shell ionization by solar-wind protons and (4) electrons; (5) bremsstrahlung of solar-wind electrons; (6) cometary substorms; (7) collisions between cometary and interplanetary dust particles; (8) scattering, fluorescence, and bremsstrahlung by very small particles with mass in the order of 10^{-19} g; and (9) charge transfer of the solar-wind heavy ions with cometary molecules suggested by *Cravens* [1996]. Of all these processes, only scattering by very small particles and charge transfer of the solar-wind heavy ions are capable of producing the measured soft X-ray emission. In the case of very small particles, the mean particle mass of 4.6×10^{-19} g suggested by *Utterback and Kissel* [1990] should be reduced to $(1\text{-}2)\times10^{-19}$ g to be consistent with the polarization and color of comet Halley. This reduction strongly affects the visible brightness of the particles, which is proportional to m^2, with a relatively weak effect on the soft X-ray emission. We calculate the charge transfer process using the solar-wind ion densities and velocities in comet from both model of *Gombosi et al.* [1994] and the Giotto measurements of α-particles. The calculated emission constitutes 20-35% of the measured value. Spectroscopy of the X-ray emission, the He^+ 304 Å and He 522 Å lines, and cometary dust (down to 1800 Å) may help in determining the contributions of the above processes.

SPECTROSCOPY OF COMET HALE-BOPP WITH THE EXTREME ULTRAVIOLET EXPLORER SATELLITE

V. A. Krasnopolsky, M. J. Mumma (Goddard Space Flight Center, Greenbelt), M. Abbot, B. C. Flynn (Center for EUV Astrophysics, Berkeley), P. D. Feldman (Johns Hopkins Univ., Baltimore), C. B. Cosmovici (Istituto di Fisica dello Spazio, Italy)

The EUVE observations of comet Hale-Bopp result in a detection of He 584 Å and O^+ 539 Å, both with signal-to-noise ratios of 4. The helium line intensity corresponds to the helium production rate of $(2\pm1)\times10^{26}$ s^{-1} and $He/O=1.5\times10^{-4}$ in the comet. Compared with the solar ratio of 110, this means a depletion of helium by six orders of magnitude relative to the solar abundance. Either helium was adsorbed by the comet during its formation or it is the solar-wind α-particles neutralized in the comet. The O^+ 539 Å line intensity is similar to that produced by prompt photoionization excitation of neutral oxygen. The absence of the neon lines leads to a 2-sigma upper limit of 4×10^{27} s^{-1} for the production of neon in the comet. Then $Ne/O<3.7\times10^{-3}$, and neon is depleted relative the solar abundance (Ne/O=0.15) by more than a factor of 40. This is the first sensitive limit to the neon abundance in comets. It means that comet Hale-Bopp experienced temperatures about 40 K or higher before it reached the inner solar system. The comet was also detected by the satellite imaging instrument operating in the soft X-ray range of 70-180 eV. The observed X-ray emission is equal to 3×10^{25} ph/s for an aperture of 10^4 km. Scaling the X-ray emission of comet Hyakutake observed with the ROSAT satellite (Lisse *et al.* 1996) to the gas and dust production rates and heliocentric distances of both comets, we find that efficiencies of X-ray excitation in both comets are similar.

COMPUTER MODELING OF THE SMALL BODY DYNAMICS. STOCHASTIC MODELS AND ALGORITHMS

N.V.Kulikova, A.V.Mychev (Institute of Nuclear Power Engineering, Obninsk, Kaluga region, Russia)

A real stochastic model of the dynamics of Phaeton and Geminids is considered. Computer modeling is performed by a Monte-Carlo method according to Bernoulli's scheme. The dynamics of these objects is described by Keplerian's probability space. The method of cross-sections in a probability space is used to analyze the space-time characteristics. The unique solutions are obtained from performed computer experiments.

PHYSICAL PROPERTIES OF NEAR-EARTH ASTEROIDS: UPDATED RESULTS

D.F. Lupishko (Astron. Observatory of Kharkov State University, Sumskaya str. 35, Kharkov 310022, Ukraine)

About 400 near-Earth asteroids (NEAs) have been discovered till now and their discovery rate is continuously increasing. The review collects and summarizes the most important new data on physical properties of this asteroid population, obtained by photometric, polarimetric, spectroscopic, radar and other techniques. Available data show that shapes, rotation and optical properties of NEAs on the average are practically the same as those of main-belt ones. But among NEAs there are objects with unusual shapes (very elongated, bifurcated and binary), with very complex non-principal axis rotation (tumbling asteroids) and with peculiar optical properties. The radar data suppose that a substantial part of NEAs could be the binary systems. Among the classified NEAs there are almost all known taxonomic types including objects of V-type (differentiated matter), M-type (metallic), Q-type (analogues of ordinary chondrites), and the primitive matter asteroids (contained some organic materials and opaques) of F and D-type, which can supply a flux of organic to the Earth. The study of physical properties of NEAs is very important for understanding their dynamical history, their relation to comets and meteors, and for the analysis and solution of new applied topics like the asteroid hazard problem, and the possibility to use near-Earth asteroids in the future as sources of metal and other raw materials in the near-Earth space.

DUST INFLUX TO TITAN: THE HYPERION SOURCE

Alexander V. Krivov (St. Petersburg Univ., 198904 St. Petersburg, Russia)
Marek Banaszkiewicz (Space Research Centre, 00-716 Warsaw, Poland)

We investigate the sources of dust in the outer saturnian system and delivery of dust material to Titan. The neighboring Hyperion may act as the most effective dust supplier for Titan. Hypervelocity impacts of dust particles coming from the outermost moon Phoebe and bombardment by IDPs should produce impact ejecta from Hyperion's surface, an appreciable share of which would escape into the planetocentric orbits initially close to that of Hyperion. Though the particles would initially be locked in a strong 4:3 mean motion resonance with Titan so that encounters with this satellite would be prohibited, the solar radiation pressure and especially plasma drag force destroy the resonant locking. Once the resonance is broken, the orbits become unstable and experience multiple close approaches to Titan. Using numerical integrations, we performed a statistical study of the grain trajectories to find out the eventual fate of the debris and to construct a spatial distribution of dust in the Hyperion-Titan system. Most of the grains larger than $\sim 5\mu m$ finally collide with Titan, whereas smaller particles either escape to interplanetary space or hit Saturn. A steady-state dust cloud in the Hyperion-Titan system is tilted off the equatorial plane of Saturn and has a structure that depends on the particle radii. Our estimates of the dust influx to Titan show that the upper limit of the income rate of the Hyperion particles may considerably exceed the direct influx of IDPs. The influx of icy (H_2O) particles from Hyperion is suggested as a possible explanation of the observed abundance of CO_2 molecules in Titan's atmosphere.

RESEARCH OF METEOR FRAGMENTATION FROM PHASE REGISTRATIONS OF METEOR RADIO REFLECTIONS

A.R. Kurganov, A.V. Kapralov and A.M. Stepanov (Department of Physics, Kazan state university, Kremlevskaya st., 18, Kazan, 420008, Russia)

The methods of registration of meteor fragmentation for optical meteors were simple, that's why these characteristics of optical meteors are well-known. The research of fragmentation of radio meteors were mainly based on the analysis of its amplitude-time characteristics. The our additional analysis of phase-time characteristics of radio meteor reflections has allowed to investigate the thin effects of fragmentation of meteor particles. The meteor radar of the Kazan university (frequency 32 MHz, pulsing power 150 kW, frequency of pulses 400 Hz) has given the sufficient material on phase and amplitude registations of radio meteors on range of weights 0.0001-0.1 gr for sporadic and fluxing meteors. There were registered the phase-amplitude characteristics, the horizontal coordinates and the hight of meteor trail, as well as speed of meteor particles for each radio meteor. The fragmentation of meteor particles causes the distortion of diffractional curves of the phase-amplitude characteristics at 0-0.3 c. The data on 3000 amplitude and phase registrations of radio meteors have shown that the probability of fragmentation drops with the reduction of particle weight. The fragmentation of particles happens in form "husking" and very rarely in kind of "flare" for radio meteors. The probability of fragmentation of the Geminid stream particles much more, than of the Quadrantid stream ones. This fact is connected with the particles distinction of chemical structures and mechanical structures.

THE SCHWARZSCHILD PROBLEM; A MODEL FOR THE MOTION OF SMALL BODIES IN THE SOLAR SYSTEM

V.Mioc and M.Stavinschi (Astronomical Institute of the Romanian Academy, Str.Cuţitul de Argint 5, 75212 Bucureşti 28, Romania)

The motion in a field featured by a force function $A/r+B/r^3$ (the Schwarzschild problem) constitutes a realistic model for the dynamics in the relativistic solar gravitational field. A qualitative study is performed by using the powerful tool of McGehee's transformations. The local flow on collision and infinity manifolds is described, allowing the study of orbits with very large eccentricities. For the case of parabolic-type motion, the global flow can be described. This qualititive analysis is very useful to the understanding of the motion of certain small bodies of the solar system (comets, some asteroids) at very small and very large distances from the Sun.

The 46 P/Wirtanen Nucleus Reference Model

D. Möhlmann

Nucleus and surace properties have to be modelled to have a first basis for designing a comet surface lander for the target comet 46 P/Wirtanen of the ROSETTA-mission. Within the preparations to the original RoLand Comet Lander Project, a first version of a nucleus reference model has been prepared. The main outcomes of this model will be presented by the invited paper. The Nucleus Reference Model describes with special emphasis to the above mentioned target comet global nucleus properties, as orbital elements, astronomical appearance and properties, the specific importance of this comet nucleus, size, shape,mass, mass density, rotation, internal properties, the near surface gravitational field, mechanical properties and structural properties, origin of comet nuclei, thermal properties, electric -, magnetic -, and electromagnetic properties, and chemical and mineralogical composition. Surface properties, as surface temperatures, mechanical properties of different surface types, thermal and electromagnetic properties, outgassing related properties, and surface forming processes and related surface topography are further subjects of this Nucleus Reference Model.

Origin of comets and Kuiper-belt objects

D. Möhlmann

Local regions or dust/particle ensembles of the extended preplanetary dust subdisk at distances of about 100 AU and of sizes of the order of about 108 m are shown to be prone to gravitational instability to occur with characteristic time scales of the order of hundred years. Gravitational stirring limits the growth of the bodies at sizes of several hundred meters to a few kilometers before the ensemble dissolves. These are the cometary and Kuiper-belt objects "building bodies". Resulting properties of comet nuclei and Kuiper-belt objects are discussed.

DYNAMICS OF SMALL BODIES. THE STOCHASTIC METHOD

A.V.Mychev, N.V.Kulikova (Institute of Nuclear Power Engineering, Obninsk, Kaluga region, Russia)

The stochastic methods for formalizing mathematical models of the dynamics of small bodies are developed. The behaviour of considered dynamic systems is studied in a probability space formed in the range of values of Keplerian orbital elements. This mathematical model is solved as a mathematical expectation in Keplerian's probability space. An algorithm obtained according to Bernoulli's scheme is suggested for estimating the probability measure. New concepts in the dynamics of small bodies are introduced, i.e. the criterion of trajectory stationarity from a probability measure and the measure of trajectory compactness in Keplerian's probability space. The proposed method is illustrated by results of computer modeling for real dynamic systems of small bodies.

DISINTEGRATION SCENARIO OF LARGE DUST AGGREGATES BASED ON THE VEGA-2 ELECTRIC FIELD RECORDS

P. Oberc (Space Research Centre, Bartycka 18A, 00-716 Warsaw, POLAND) e-mail: poberc@cbk.waw.pl

Simultaneous dust and electric field observations on Vega-2 have allowed to establish the mechanisms, by means of which the two double probe antennas, short (APV-N) and long (APV-V), responded to plasma clouds generated by dust impacts. The antennas responded mostly to particles in the range 1.E-10-1.E-7g and the target area for impacts was comparable to the whole spacecraft projection. Electric field records of Vega-2 include also ~20 conspicuous events in which the dust flux was high enough that impacts became continuous and sensitivity of the antennas to discrete (large) impacts was strongly reduced. High resolution APV-N waveforms demonstrate that the respective dust formations consisted of a sequence of clouds. Morphological properties and mass estimates lead to the conclusion that these dust structures (with dimensions of 200-300 km) originated due to at least two-step disintegration of aggregates with masses comparable to the biggest liftable mass (~100 kg). We show that the largest fragments (with m~1-10 kg), released sporadically from the parent grain at the first step of disintegration, were getting distributed along a syndyne and, being subject to the second (next) step(s) of disintegration, developed a sequence of dust clouds. Some details of this scenario and its compatibility with the model of the dust boundary (Icarus, 124, 195-208, 1996) will be discussed.

CONSERT EXPERIMENT: ANALOG SECTION

G.Picardi, R.Seu

Purpose of this paper is to verify the feasibility of the analog section for= the proposal related to Consert experiment to be held in the ROSETTA= mission. The rationale behind this feasibility verification is to propose a well= known and reliable hardware which could allow, even in worst environmental= conditions, as the case for a deep space mission, to guarantee = satisfactory performance both from the information point of view and for= the constraints posed on the mission (see for instance mass and power= allocation). Proven and used technology will be the basis for this approach together = with a proper strategy to heavy constraint on the mission. The Alenia= Spazio experience of the Cassini mission in the hardware implementation of= the radar system will be taken as starting point. In this paper the =93nominal6.doc=94,prepared by Y.Barbin, F.Wicek and= W.Kofman (5/11/96) and the =93Notes on the feasibility for Rosetta-Consert= TX-RX design=94 (28/9/96) prepared by. L.Borgarelli of Alenia Spazio are= taken in account as reference. Conclusions will be assessed mainly for budget alloccation (mass and power).

POLARIZATION PROPERTIES OF THE GALILEAN SATELLITES OF JUPITER: OBSERVATIONS AND PRELIMINARY ANALYSIS

V. K. Rosenbush, Main Astronomical Observatory, Kiev
V. V. Avramchuk, Main Astronomical Observatory, Kiev
A. E. Rosenbush, Main Astronomical Observatory, Kiev
M. I. Mishchenko, NASA Goddard Institute for Space Studies, New York

We present new detailed polarimetric measurements of the Galilean satellites of Jupiter with U, B, V, and R filters at phase angles ranging from 12° to nearly 0°. The polarization phase curves of Io, Europa, and Ganymede in the B, V, and R filters clearly show the presence of a sharp peak of negative polarization centered at a very small phase angle of $\alpha \approx 0.6°$-$0.7°$. This phase angle is comparable to the width of the spike-like photometric opposition effect observed for Europa, thus indicating that both features are likely to be produced by the coherent backscattering mechanism. Io, Europa, and Ganymede exhibit a noticeable polarization at the inversion angle, thus suggesting that the rotation of the polarization plane by 90° at the inversion angle occurs smoothly rather than stepwise, albeit quite fast. The U values of $|P_{min}|$ for Io and Europa are close to 0.60% and 0.47%, respectively, and exceed the respective BVR values by a factor of almost 2. The BVR polarization for the trailing hemisphere of Io, Europa, and Ganymede is systematically stronger than that for the leading hemisphere. For Callisto, the leading hemisphere polarization is significantly stronger than that for the trailing hemisphere. The inversion angles for Io, Europa, and Ganymede are nearly wavelength-independent and close to 10°, 8.6°, and 8.8°, respectively.

HALE-BOPP OBSERVATIONS WITH INTERFERENCE FILTERS

P. Rousselot, C. Laffont, G. Moreels, J. Clairemidi (Observatoire de Besançon, BP 1615, 25010 Besançon Cedex, France)

Comet Hale-Bopp was observed in August, September and October 1996 with the 1.20 m telescope of the Observatory of Haute-Provence (France). The observations were conducted in imagery mode with 5 narrow-band filters located at 513, 514, 516 nm (corresponding to the wavelengths of the C_2 Swan bands) and at 527 and 682 nm (corresponding to the continuum). Some spectra were also taken with the 1.93 m telescope around the C_2 Swan bands. The data reveal mainly : (i) a roughly isotropic increase in the C_2 excitation temperature (obtained in computing the ratio Intensity(513 nm)/Intensity(516 nm) after subtraction of the continuum), (ii) a similar increase in the dust color (Intensity(682 nm)/Intensity(527 nm)) and (iii) an interesting feature when the gas/dust ratio is mapped: a big dust jet (about 300 000 km long) in the tail side. Using a model of C_2 developed in the laboratory, the I(513)/I(516) maps are interpreted in term of "fresh" C_2 molecules reaching their fluorescence equilibrium.

MONITORING OF ROSETTA TARGET 46P/WIRTANEN

R. Schulz (ESA Space Sci. Dep. ESTEC, Noordwijk, The Netherlands)
H. Boehnhardt (Inst. for Astron. and Astrophys., Univ. München, Germany on behalf of the Wirtanen Observing Team at ESO

In 2003 the International Rosetta Mission will be launched to rendez-vous with the nucleus of comet 46P/Wirtanen at around 4.9 AU and study its properties and the evolution of the coma from the onset of activity beyond 3 AU through perihelion. This mission will provide an unprecedented, unique data set of space experiments regarding a single comet. For the great majority of comets, however, only measurements made by ground-based telescopes will be available. It is therefore important to establish the proper correlation between the spacecraft measurements and the data that can be obtained by ground-based observations and transfer what is learned also to other comets. Comet 46P/Wirtanen was monitored by broad-band imaging and spectroscopy from ESO, La Silla, through 1996 while it was moving along that part of its orbit that will be covered by the space mission. The data are of immediate use to derive some basic properties of the comet which are vital for the successful design and execution of the mission. However, they are also important to study a short-period comet along a significant part of its orbit and, in the long term, to establish the link between the results of *in-situ* measurements ground-based monitoring of comets. The first results of the brightness and compositional evolution of 46P/Wirtanen are presented and discussed in view to the space mission and compared to other comets.

THE COSMIC DUST ANALYSER FOR CASSINI

R. Srama, E. Grün (Max-Planck-Institut für Kernphysik, Postf. 10 39 80, 69029 Heidelberg, Germany) and the CASSINI-Dust-Science-Team

The „Cosmic Dust Analyser" (CDA) will be launched onboard CASSINI in October 1997. This instrument can detect and analyse interplanetary, interstellar, Jovian and Saturn dust fluxes. With its sensitive area of 0.1 m^2, fluxes as low as 1 impact/month can be detected. The measurement of the dust characteristics mass (10^{-15} - 10^{-9} g), electric charge (10^{-15} - 10^{-12} C), chemical composition (mass resolution 20-50) and speed (1-100 km/s) is accomplished by using impact ionisation. A High Rate Detector (HRD) is used to detect high impact rates. The flight unit and engineering unit instrument status and precalibration results from measurements at the Max-Planck-Insitut dust accelerator facility are presented.

PARTICLE SIZE DEPENDENCE OF SPECTRAL SLOPE AND BAND DEPTHS: IMPLICATION FOR SPECTROSCOPY OF AIRLESS BODIES

L.V. Starukhina, Yu.G. Shkuratov. (Astronomical Observatory, Sumskaja 35, Kharkov, 310022, Ukraine) and L.V. Moroz (DLR Institut für Planetenerkundung, Rudower Chaussee 5, D-12484 Berlin, Germany)

Among the reflectance spectral parameters of particulate surfaces only albedo is generally considered as particle size dependent. Such a dependence for the other spectral parameters - relative band depths and spectral slopes (color indices) - has not yet been quantitatively studied. To study it we used theoretical model of spectral reflectance for particulate surfaces (1). Calculations have shown that both color indices and band depths are particle size dependent. Spectral contrasts are minimal for small and large particles and have a maximum at intermediate size as expected, because surfaces with very large or very small particles are too dark or too bright, respectively, to show great spectral contrast. Maximum position is shown to shift to smaller particle size with increasing band intensity. The particle size dependence is weak only in the case of not pronounced spectral slope. These results are experimentally illustrated by IR reflectance spectra of 5 size fractions of asphaltite which spectrally resembles organic matter of comets and distant asteroids (2,3). Particle size dependence of color indices and band depths should be taken into account in interpretation of spectra of solid surfaces.

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ON ELECTRIC CHARGES OF NON-SPHERICAL DUST PARTICLES

J. Svestka (Prague Observatory, Petrin 205, 11846 Prague 1, Czech Republic)
E. Grün (MPI-K, Postfach 103980, 69029 Heidelberg, Germany)
J. Kubelik (JK Group, K Hrncirum 55, 14900 Prague 4, Czech Republic)

Dust particles in space are generally electrically charged. Up to now, for a simplicity, only charges of spherical particles have been considered. Dust particles can be, however, highly non-spherical. Non-spherical particles can carry at a given potential and mass more electric charges and, therefore, can have higher charge-to-mass ratio compared to spherical ones. For example, keeping the mass and the potential constant, the total electric charge on conducting prolate and oblate spheroids increases with increasing ratio of the major to the minor axis. Charges on conducting dust particles of various shapes were calculated with help of the SIMION 6.0 program and Microsoft FORTRAN Power Station 4.0. Implications for an interpretation of signals detected by the charge grid of the Galileo dust detector are discussed.

SEARCH OF THE CORRELATIONS BETWEEN THE VARIOUS PHYSICAL AND DYNAMICAL PARAMETERS FOR THREE ASTEROID FAMILIES

E.I. Timoshkova (Institute of Theoretical Astronomy of Russian Academy of Sciences, Naberezhnaya Kutuzova 10, St.Petersburg, 191187 Russia)

The detection of the correlation relations between the various physical parameters can help to clear up a problem of the origin and evolution of the distinct asteroid populations. Early we studied the relation between the rotation period P and the diameter D for the population of the Near-Earth asteroids. In this paper the asteroids with known rotation periods P and diameters D within three largest asteroid families (Themis, Eos, Koronis) are considered. For a search of the correlation connections between P and D and another parameters a useful technique of the computation of correlation coefficients is applied. They are calculated for all asteroids from above families together in one sample and for asteroids within the individual families. Next we examine the correlations of a surface rotational velocity v_s on the asteroid equator with the orbital parameters a, e, i, the circular orbital velocity V_{cr} and a function $W(a, e, \sin i)$, which is a measure of the expected average collisional energy. It is found that the various degree of correlations between the the identical pairs of parameters exists for the distinct asteroid families. Because the number of asteroids with the known P and D within each family is essentially different the interpretation of derived correlations is prematurely.

A STATISTICALLY OPTIMIZED SET OF THE ASTEROID POLARIZATION PARAMETERS ASSOCIATED WITH PHYSICAL PROPERTIES

S.V. Vasilyev (SOLERC, P.O. Box 59, Kharkiv, 310052, Ukraine)

We have studied the problem of quantity of the independent parameters needed to explain all the differences among the assemblage of asteroid polarization phase curves. Using all available data we have found the two new parameters λ_1 and λ_2, which can reliably describe the observational polarimetric phase dependences in the phase angle range 0°÷30° and are more suitable for further analysis and physical interpretation than the widely used system of four interdependent parameters (P_{min}, α_{min}, α_0 and h). The first parameter λ_1 is near equivalent to the polarimetric slope h and is controlled by the asteroid surface albedo. Another one λ_2 has no analog among the polarimetric parameters. It correlates linearly with the asteroid diameter for S-type asteroids that may indicate its sensitivity to the changes in surface microstructure. The corresponding relation for the low-albedo asteroids is more complicated and will be discussed.

Rosetta Lander - In Situ Investigation of a Cometary Nucleus

K. Wittmann, B. Feuerbacher, S. Ulamec (DLR, D-51140 Köln, FRG)
H. Rosenbauer (Max Planck Inst. f. Aeronomy, D-37191, Lindau, FRG)
G. Haerendel; (Max Planck I. f. Extrter. Phys., D-85740 Garching, FRG)
J.P. Bibring (IAS)
R. Mugnuolo, (ASI, I-75100 Matera, Italy)
D. Moura, (CNES, F-31055 Toulouse, France)

The ESA cornerstone mission Rosetta to comet P/Wirtanen will include a unique surface science station, the Rosetta Lander, which will allow to measure the chemical, physical and mineralogical properties of material at and closely below the cometary surface, the internal structure of the nucleus and take images of the landing site.
After ejection from the Rosetta Orbiter, the Rosetta Lander will descend to the surface of the target comet. Low temperature solar cells, covering the surface of the lander, and batteries will provide power sufficient to operate a payload of over 20 kg. The lander is an autonomous station, that will be designed to operate for several months, transmitting data via the Rosetta orbiter to Earth. Due to its longevity it is possible to study time-dependent cometary phenomena and to investigate modifications of the surface due to increasing insolation.
The Rosetta mission originally foresaw to carry two landers (Champollion and RoLand), 45 kg each. However, due to the withdrawal of Champollion, there will now be one such device, combining as much of the science as possible and staying within 75 kg. It will be based on the former RoLand design

The Detection of ß-meteoroids with the Ulysses Dust Experiment

A Wehry, I. Mann, K. Scherer (Max-Planck-Institut für Aeronomie, Postfach 20, D-37189 Katlenburg-Lindau, Germany)

Cosmic dust particles are leaving the solar system in hyperbolic orbits, if the repelling radiation pressure force exceeds solar gravity. This applies especially for small particles because of the radiation pressure being in the same order of magnitude as the solar gravity. These so-called ß-meteoroids can be produced either by emission from comets or by collision of bigger objects. The sublimation of near solar dust provides a further source of ß-meteoroids. Hence the fluxrate and the velocity distribution of the ß-meteoroids yield information about the evolution of the inner solar system dust cloud. The outer solar system ß-meteoroids are possibly proved by impact measurement of the dust detector on the Ulysses-spacecraft (Grün et al. 1995). We calculate the detection probabilities for possible fluxes of ß-meteoroids and compare them to available analysis by Baguhl (1993). In conclusion the flux of ß-meteoroids outside of the earth orbit will be estimated.

PS8 Solar system radiophysics and related topics

Convener: Rucker, H.O.
Co-Convener: Barrow, C.H.

SPECTRAL FEATURES OF THE SOLAR DECAMETER BURSTS

E.P.Abranin, L.L.Bazelyan, V.N.Lisachenko, *V.N.Mel'nik* (Institute of Radio Astronomy of National Academy of Sciences of Ukraine, Chervonopraporna str.4,310002, Kharkiv, Ukraine)

Results of the spectral analysis of about 400 solar microbursts at low frequences $f = 10 \div 25$ MHz with dynamic range 40 dB, sensitivity 100 Jy and the constant time 0.1 s are presented. Multydimansional correlation analysis of these bursts were used. There are three clusters of bursts: Type 111 bursts 1) at the fundamental frequency; 2) at the second harmonics and 3) reflacted bursts at the second harmonics. Microbursts are attracted to 1) cluster on the whole and to 2) one rarely. These bursts can be fallen into 4 groups according their spectral features: i)bursts that appear at $f > 25$MHz with spectral indexes $\alpha \approx -6 \div -2$; ii) bursts that appear at $f < 25$ MHz with the same spectral indexes; iii) bursts that disappear at $f = 10 \div 25$ MHz with final indexes $\alpha > 0$ at the final stage; iv) bursts that appear and disappear in the range 10-25MHz. Interpretation of these types of microbursts is presented.

Jovian decametric emission observed simultaneously from the Earth and from Wind spacecraft

M. Aubier (Observatoire de Meudon, F-92195 Meudon, France), M.Y. Boudjada, (Space Research Institute, A-8010 Graz, Austria), A. Lecacheux, (Observatoire de Meudon, F-92195 Meudon, France), H.O. Rucker, (Space Research Institute, A-8010 Graz, Austria), M.L. Kaiser, (NASA/GSFC, MD, 20771, USA), A. Gerbault (Station de Radioastronomie de Nancay, F-18330 Nancay, France).

Jovian decametric emission (DAM) is compared, for similar configurations of central meridian longitude (CML) and Io-phase, observed from WAVES experiment on Wind spacecraft and from Nancay radiotelescope. This analysis is based on observations recorded from 06/12/95 to 31/07/96. The large coverage in frequency range, from 1 to 13.8 MHz on WAVES experiment and from 10 to 40 MHz at Nancay station, allows to analyse the complete dynamic spectra of Jovian decametric emission. We show the change in the occurrence probability of DAM emission in the { CML,Io-phase} diagram which is influenced by the geometry configuration Jupiter, Io-satellite, and the observer, e.g. Earth or Wind spacecraft. On the other hand, we study the arc structures of Io-controlled sources which are compared with recent results (Lecacheux et al., 1996) and previous ground/Voyager observations.

A new approach to determine the S-burst drift rates from observations

M.Y. Boudjada, H.O. Rucker, (Space Research Institute, A-8010 Graz, Austria), P.H.M. Galopeau, (Centre d'Étude des Environnements Terrestre et Planétaires, F-78140 Vélizy, France),
M. Aubier, (Observatoire de Meudon, F-92195, France)
V. Mostetschnig, (Space Research Institute, A-8010 Graz, Austria).

We report on the analysis of Jovian millisecond radio bursts (S-bursts) observed at the radio station Graz-Lustbühel on January 4th, 1993. The observation was performed by a multichannel receiver with high time resolution of 2 ms sufficient to resolve the individual S-bursts.
We show, from these observations, that two systematic errors usually have been introduced in the determinations of the S-burst drift rates. The first uncertainty derives from analogical observations and limited frequency bandwidth, which involves an incorrect identification of the type of S-burst. The second uncertainty is directly connected to the classic method which does not consider the spectral environment of the millisecond burst, e.g. S-burst patterns and L-bursts. We conclude by this new approach towards a better estimation of the S-burst drift rates.

FINE STRUCTURE OF BIG SOLAR RADIO BURSTS IN A CONNECTION WITH CORONAL MASS EJECTIONS

Guennadi CHERNOV, A.K.Markeev
(IZMIRAN, Troitsk, Moscow Region, 142092, Russia)

The fine structure of solar type II+IV radio burtst was discovered in the direct connection with events of Coronal Mass Ejections (CME). For the analysis 18 events were selected when the identification of radio sources with flares was enough simple and when the information about CME was known (using Solwind and SMM data). It was discovered that in direct connection with CMEs slow drifting fibers in type II bursts or in flare continuum FCII are observed at the impulsive phase of events, or rope like fiber bursts which are accompanied by unusual low drifting fibers in absorption and millisecond broad band pulsations at post maximum phase. Zebra-pattern at unusually low frequencies (up to 45 MHz) was also observed in such events. The consideration of some models of radio emission of those fine structures confirms such their direct connection with CMEs in frames of well accepted radio emission mechanisms of loss-cone electrostatic and whistler wave instabilities. Observations of such fine structure could be used as an additional diagnostic tool for CMEs by means of radio emission.

INTERPLANETARY SCATTERING EFFECTS IN THE JOVIAN BKOM RADIO EMISSION

C. H. Barrow (Max Planck Institute for Aeronomy, D-37189 Katlenburg-Lindau), G. Woan (Department of Physics and Astronomy, University of Glasgow, U.K), and R. J. MacDowall (NASA/Goddard Space Flight Center, Greenbelt, MD 20771)

Radio astronomy observations of fine structures at kHz frequencies are limited by the effects of interplanetary scattering which cause a range of arrival times for the radiation from a transient event and broadening of temporal features. From Earth, this broadening τ_b is expected to increase with decreasing frequency as $\tau_b = 0.1 f^{-4.4}$ down to some 200 kHz when τ_b would be about 2 minutes. Below this frequency τ_b would tend to reach a limiting value of about 10 minutes as the overall scattering angle increases and can no longer be assumed to be small. We have used observations of the jovian broad-band kilometric radiation (bKOM), by the Unified Radio and Plasma Experiment (URAP) on board ULYSSES, as a means of investigating the observational constraints imposed by scattering in the interplanetary medium at kHz frequencies. The durations of bKOM structures observed at different frequencies, during 1995 when the spacecraft was at distances greater than 5 AU from the planet, have been compared with observations made in 1991 when Ulysses was approaching Jupiter at distances close to 1 AU. We can occasionally measure the characteristic decay times of apparently broadened profiles, giving information on both the density and the distribution of the interplanetary medium between Jupiter and the spacecraft. Recent results are reported and discussed.

Diagnostics of the Solar Coronal Plasma Through Coordinated Multiwavelength Observations

M.Y. Boudjada(1), A. Cacciani(2), A. Hanslmeier(3), G. Mann(4), M. Messerotti(5), P. Moretti(2), Th. Pettauer(3), H.O. Rucker(1), P. Zlobec (5)
1 Space Research Institute, 8010 Graz, Austria
2 Dipartimento di Fisica, Universita' "La Sapienza", Rome, Italy
3 Institut fuer Astronomie, Karl Franzens Universitaet, Graz, Austria
4 Astrophysikalisches Institut Potsdam, Potsdam, FRG
5 Osservatorio Astronomico di Trieste, Trieste, Italy

The solar corona exhibits a complex variety of features, which occur at different spatial and temporal scales ranging from subarcseconds to solar radii and from milliseconds to days, respectively. The current space missions like, e.g., SOHO, provide an unprecedented opportunity to study such phenomenology in different spectral ranges with a high level of detail through a set of complementary experiments. Dynamic activity phenomena on the disk can be observed by the experiment SUMER with high space and time resolution, and large scale structures of the extended corona are mapped by UVCS up to 10 solar radii. A global modelling approach of coronal plasma processes needs complementary information which can be provided by ground- based radio observations. These will be carried out in Graz (A) as well as at Trieste (I) and Potsdam (FRG), providing diagnostics of the high to the low corona. Vector magnetograms will be obtained at the Solar Observatory Kanzelhoehe (A). Details of the above instruments and the relevant complementary diagnostics will be discussed.

PROPAGATION OF WHISTLERS IN THE JOVIAN MAGNETOSPHERE/IONOSPHERE AND JOVIAN LIGHTNING

Y. Hobara, O. A. Molchanov and M. Hayakawa (The University of Electro-communications 1-5-1, Chofugaoka, Chofu-city Tokyo 182, Japan)

In this paper we extensively reexamine the amplitude of many whistlers detected by the Voyager 1, and try to understand the propagation characteristics of the lightning-generated whistlers in the Jovian ionosphere and magnetosphere especially focusing on its wave amplitude and to deduce information about the causative lightning discharges with the use of our ray-tracing computations taking into account all amplitude information (focusing/defocusing effect, polarization effect and kinetic collisionless damping effect consisting of Landau and cyclotron dampings). As a result, we have derived the frequency spectra and mean radiation power of the causative lightning discharges, and have also applied statistical method to the analysis. We can summarize our findings in the following.
The average power flux spectral density of the whistlers falls in the range from 10^{-127} $V^2m^{-2}Hz^{-1}$ to 10^{-110} $V^2m^{-2}Hz^{-1}$.
We calculated the total decrease of the whistler amplitude from the bottom of the ionosphere toward the spacecraft, as a range from about 30 to 40 dB depending on the observed region.
One of the strongest estimated lightning events exhibits a frequency dependence comparable to the terrestrial one, but its peak frequency seems to be similar to the upward current strokes on the Earth.
Other events possibly have features similar to those of the terrestrial return strokes. We calculated the mean radiation power per flash of the lightning in the Jovian atmosphere for a 1-kHz bandwidth over 60 msec, as a range from the order of 10^2 to 10^5W.
The probability distribution of the radiation power in Jupiter exhibits a lognormal distribution, just as in the terrestrial case.

Wind/WAVES Observations of Jovian Radio Emissions

M. L. Kaiser (NASA/Goddard Space Flight Center, Code 695, Greenbelt, MD, 20771, USA), L. Garcia (U of Florida, Gainesville, FL, 36211, USA), A. Lecacheux and P. Zarka (Observatoire de Paris, Meudon, 92195, France)

The Wind spacecraft, launched into a complex Earth orbit in November, 1994, carries many fields and particles instruments including WAVES, a comprehensive radio receiver which covers the frequency range from near DC to 14 MHz. WAVES easily detects Jovian HOM and DAM emissions. These Jovian observations since launch have been made from an area of frequency -DE observing space that has not been adequately sampled in the past. In this observing space at the low end of the DAM frequency range, the traditional Io-A and B sources nearly disappear and Io-C and D become dominant. Analysis of the position of Io's footprint during these observations shows that these emissions must come from the southern auroral region of Jupiter.

A STEADY SOLUTION FOR ELECTRON BEAM PROPAGATING IN CORONA PLASMA: NUMERICAL AND ANALYTICAL CONSIDERATION

E.P. Kontar and V.I. Lapshin (*Kharkov State University, 310077, Kharkov, Ukraine*)
V.N. Mel'nik (*Institute of Radio Astronomy of National Academy of Sciences, 310002, Kharkov, Ukraine*)

Electron beams propagating in solar corona and interplanetary space generate plasma waves that become a source of radio emission. The conditions in corona give that the time of the quasilinear time is much smaller than the time of their propagation in interplanetary space and the electron beam should decay for a short time. However the numerical computations fulfilled show that the kinetic equations of weak turbulence have a steady solution that can explain long time existence of electron beams in corona. It is found out that the maximum of electron density propagates with the constant speed equal to the average velocity of plateau electrons and the shape of the initial spatial distribution slightly changes in time. The spectral energy density obtained has two peaks at the injection point and at the point corresponding to the electron density maximum. Plasma waves generated by the first electrons arrived in the point are completely absorbed by the slow electrons that accelerates particles and conserves their total number. The comparison of analytical results with the results of the numerical simulations is discussed

NEW OBSERVATIONS OF SKR WITH ULYSSES: DID THE SIDEREAL ROTATION PERIOD OF SATURN REALLY CHANGE?

A.Lecacheux (CNRS URA 1757-Observatoire de Paris/Meudon, 92195 Meudon, France)

Due to its excellent sensitivity, the URAP radioastronomy experiment aboard the *Ulysses* interplanetary spacecraft, regularly detects kilometric radio emissions coming from Saturn. The auroral, kilometric radiation of Saturn (SKR), discovered in 1980 by *Voyager 1*, is strongly modulated by the planetary spin, like most of the planetary, auroral radio emissions. Thus, the SKR radio period, deduced from the *Voyager* observations, was identified with the rotation period of Saturn and used to establish a value, presumed accurate at a few seconds, of the sidereal rotation period of the planet. However, the new SKR observations by *Ulysses*, extending from January 1994 to July 1996, exhibit a constant, well-defined radio period, which is about 1% slower than the former value. After a review of the new measurements and a discussion of their accuracy, the implications of the result are discussed.

MODELLING OF ENERGETIC PROCESSES IN AN ENSEMBLE OF INTERACTING MAGNETIC LOOPS

M.L.Khodachenko, V.V.Zaitsev (Institute of Applied Physics, RAS, Ulyanova st. 46, Nizhny Novgorod 603600, Russia)
L.Vlahos (Department of Physics, University of Thessaloniki, 54006 Thessaloniki, Greece)

Basing on the ideas of the global approach to the dynamics and energetics of solar and stellar active regions, taking into account their complex self-consistent evolution, a structure of magnetic field of an active region was represented as an ensemble of magnetically interacting due to the mutual indaction effects current-carrying magnetic loops. Each loop in its turn was modelled by an equivalent electric circuit with variable parameters depending on the form, scale, position of the loop in the ensemble, as well as on the plasma temperature and density in the magnetic tube. Dy means of such a model the energetic and related radiation processes in the magnetic loops of an ensemble, caused by rising of one of the loops were considered. In particular, it was shown that any rising magnetic loop could cause a flare-like heating of certain loops which could be observed in soft X-ray band, as well as cooling of some other loops in the ensemble.

NON-THERMAL MICROWAVE SOLAR EMISSION FROM PLAGE-ASSOCIATED SOURCES AND THEIR MODELLING

A.N.Korzhavin, T.I.Kaltman and A.A.Stepanov (Special Astrophysical Observatory, St.Petersburg Branch, Pulkovo, St.Petersburg, 196140, Russia)

It is well known that at the microwaves there is an enhanced brightness temperature of the Sun in the plage-associated active regions. It is generally agreed that this is due to a slightly enhanced electron density in the solar corona above plages. In the frames of bremstrahlung brightness temperature of the optically thin plage-associated source increases as λ^2, that have been observed in some cases. Here we present the results of the observations of a magneticaly bipolar plage region with a filament. These observations were carried out in September-October, 1996, with high spatial resolution in the wide range of the wavelengths (2-20cm) with the radio telescope RATAN-600. At the shortest wavelengths it was observed the filament only as a dark formation. On the longer wavelengths on the both sides of the filament two sources with the enhanced radio brightness appear with the increase of the brightness temperature as λ^3 suggesting that the character of this emission is non-thermal. The observed radio brightness distributions were modelled as a combined action of bremsstrahlung and non-thermal gyrosynchrotron radio emission of a large coronal magnetic loop filled both with a thermal plasma and with a few amount of subrelativistic electrons. A good accordance between the model calculations and the observations as well as the considerable stability of the phenomenon (more then two solar rotations) indicate that there are the non-thermal processes continuously acting in the solar corona in the period of deep minimum of solar activity.

NOVEL DATA SOURCES FOR STUDIES OF TRANSIONOSPHERIC PROPAGATION CONDITIONS FOR PLANETARY SIGNALS

R. Leitinger (Institut für Meteorologie und Geophysik, University of Graz, Halbärthgasse 1, A–8010 Graz, Austria)

The most important quantity for transionospheric propagation studies is the vertical electron content (TEC). It was observed by means of the Faraday effect on the VHF signals of geostationary satellites or (to a lesser degree) the Diff. Doppler effect on signals of polar orbiting satellites. The geostationary VHF beacons have disappeared.
An important new data source are the Global Navigation Satellite Systems (GNSS). They provide electron content with a regionally dense coverage. Careful calibration considerations are necessary to gain TEC with good reliability and accuracy.
Ground based **ionospheric tomography** makes use of the polar orbiting NNSS satellites. Their movement gives one "scan", a meridional chain of receivers on the ground gives the intersecting ray bundles for tomographic reconstruction. Space tomography uses occultation of GPS (GLONASS) signals received on board of a low orbiting (LEO) satellite. Classical inversion provides an average height profile of electron density. Consecutive occultations can lead to intersection of ray bundles. Otherwise the combination of occultation data with ground based data can be used for ionospheric tomography. One receiver (GPS-MET) is in orbit already now and more receivers will be launched in the near future.

CRITICAL POINT OF THE SOLAR WIND FROM THE RADIOASTRONOMICAL DATA

N.A Lotova (Institute of Terrestrial Magnetizm, Ionosphere and Radio Wave Propagation, Troitsk, Moscow Region, 142092, Russia)
K.V.Vladimirskii (Lebedev Physical Institute, Leninsky prosp.53, Moscow, 117924, Russia)

A new approach to determine the sub-to supersound transition point in the solar supercorona is proposed. Data on the characteristic peculiarity, sharp minimum in the radial dependence of the radio wave scattering are used, this minimum, predecessor of the solar wind transonic region, being localized close to the critical point. Cumbersome direct flow velocity determinations are used for calibration purposes only. New method makes it possible to extend greatly the total of the critical point determinations. According to the heliolatitude, solar cycle phase or momentary solar activity state, the distance of the critical point from the Sun varies over a wide range of about 10 to 20 solar radii.

A STUDY OF THE FINE STRUCTURES OF THE PLANETARY RADIO EMISSIONS

P. Louarn (Observatoire Midi-Pyrénées, Toulouse, France)

An impressive characteristic of the planetary radio emissions is the diversity and the number of the fine structures present in their dynamic spectra. From this point of view, the most remarquable example of radio emission is certainly the Jovian S-bursts. As shown by recent spatial observations, the Earth auroral kilometric radiation also presents very interesting fine structures. Their origin is still a matter of debate. It could be due to the generation process itself or to the wave propagation across the semi-transparent medium that constitutes the magnetospheric plasma.
After a presentation of the different types of fine structures, we will examine how they can be associated to the morphology of the source regions. For this purpose, we will use the model of laminar source regions studied by Louarn and Le Quéau (Planetary and Space Science, 1996) and we will try to relate the observed fine structures to the geometry and to the dynamic of the source regions

APPLICATION OF INTERPLANETARY TYPE II RADIO BURSTS IN SPACE WEATHER PREDICTION

R.J. MacDowall and A.J. Klimas (NASA/Goddard Space Flight Center, Greenbelt, MD 20771 USA)

D Lengyel-Frey (School of Medicine, Johns Hopkins University, Baltimore, MD 21287)

G Thejappa (Dept. of Astronomy, University of Maryland, College Park, MD 20742)

We report on correlations between terrestrial magnetospheric activity and low frequency solar radio emissions as observed by the ISEE-3 spacecraft. In particular, type II radio bursts, which are produced by shock-accelerated electrons in the corona and interplanetary medium, provide one of the few direct means of tracking shocks and their drivers as they propagate outward from the Sun. When these observations are available, they provide 24-48 hours advanced warning of potential geomagnetic storms that are produced when the solar ejecta impinges on the magnetosphere. Less than 50 percent of intense geomagnetic storms are preceded by type II producing shocks. In this report, we will document the details of this correlation.

A HELIOSPHERIC DENSITY MODEL AND TYPE III RADIO BURSTS

G. Mann, F. Jansen (Astrophysikalisches Institut Potsdam, Telegrafenberg A31, D-14473 Potsdam, Germany),
R. J. MacDowall, and R. G. Stone (NASA/Goddard Space Flight Center, Code 695, Greenbelt, MD 20771, USA)

A heliospheric density model is derived by evaluating the spherical solutions of magnetohydrostatic equations including the thermal pressure and the gravitational force. The model covers a range from the low corona up to 5 AU and agrees very well with observations. Such a model is required for the interpretation of solar and interplanetary radio observations since the emission of these radio radiation is regarded to be generated near the local electron plasma frequency, which is depending on the electron number density. Thus, the density model yields the radial distance of the radio source from the Sun and, consequently, the radial source velocity from the drift rate in dynamic radio spectra. The model is applied for estimating the velocity of electron beams generating solar and interplanetary type III radio bursts.

NEW MODEL OF LATITUDINAL STRUCTURE OF THE IO PLASMA TORUS

M. Moncuquet and N. Meyer-Vernet (Département de Recherche Spatiale, Observatoire de Paris, 92195 Meudon, France)
F. Bagenal (Department of Astrophysical, Planetary and Atmospheric Sciences, Boulder, Colorado)

After Ulysses passage in the Io plasma torus, the previous models (*Divine and Garrett* [1983], *Bagenal* [1994]) were found incompatible with the measured electron temperature, which strongly increases with latitude along the magnetic field lines (*Meyer-Vernet et al.*, in *Icarus* [1995]). We propose here a kinetic approach to model the latitudinal extension of such a corotating plasma, using for each species a "bi-kappa" velocity distribution, that is, a gyrotropic distribution which reads (e.g. *Summers and Thorne*, in *JGR* [1992]):

$$f(v_\parallel, v_\perp) = \frac{n}{\pi^{3/2} V_\parallel V_\perp^2} \frac{\Gamma(\kappa+1)}{\kappa^{3/2}\Gamma(\kappa-1/2)} \left[1 + \frac{v_\parallel^2}{\kappa V_\parallel^2} + \frac{v_\perp^2}{\kappa V_\perp^2}\right]^{-\kappa-1}$$

These distributions approximate Maxwellians for low energies (core at thermal equilibrium) but approximate power law distributions at high energies (non-thermal halo). Using such distributions for the Io plasma torus allows us to predict both the temperature increase along magnetic field lines and the latitudinal density profile measured by Ulysses, which is at the same time more confined around the centrifugal equator, but also has higher densities at higher latitudes, than expected with previous models. Our new model allows us to explain the ion temperature profile at Voyager 1 in the warm torus (> 6 Jovian radii) and we will also discuss its compatibility with some Galileo results.

HIGH RESOLUTION IMAGING OF IONOSPHERIC D-REGION ELECTRON DENSITIES USING A NEW RIOMETER TECHNIQUE

E.Nielsen, and T.Hagfors (Max Planck Institute for Aeronomie, D-37189 Katlenburg-Lindau, Federal Republic of Germany)

A new riometer experiment is planned to image electron density variations in the ionosphere over an area of 300x300 km with a spatial resolution of 8 km, and a temporal resolution of one second. The spatial resolution represents a considerable improvement over existing systems. The experiment employs a Mill's Cross technique not used before in riometer work: two 32 element rows of antennas form the antenna array, two 32 element Butler Matrices achieve the directionality, and cross-correlation yield the directional intensities in 1024 direction.

HELIOSPHERIC TYPE III EVENTS: A DIRECT LINK BETWEEN SOLAR FLARES AND THE SOLAR WIND

M. Poquérusse (Paris Observatory at Meudon, FRANCE)

The systematic comparison of ground data at frequencies $\gtrsim 10$ MHz with space data from ISEE 3, Ulysses and Wind at frequencies $\lesssim 10$ MHz, has uncovered an excellent correlation between high and low frequency type III bursts, offering a vivid example of ground-space synergy. This shows that solar flares are the main provider of energetic electrons into the interplanetary medium, and that electron beams are somehow stabilized against the beam–plasma instability over more than an AU. Type III bursts thus constitute free and quasi-instantaneous probes of whole magnetic flux tubes across the inner heliosphere. While Ulysses is still working, on its second orbit around the sun, the Wind spacecraft is opening the new 14-1 MHz window, giving us a direct view of the acceleration region of the solar wind. The statistical analysis of the large quantity of new data being acquired is bringing original information on the connection between flares, the corona and the solar wind.

NUMERICAL SIMULATIONS OF THE RECEPTION PROPERTIES OF THE CASSINI/HUYGENS SPACECRAFT CONFIGURATION

H.O. Rucker (Space Research Institute, Halbaerthgasse 1, A-8010 Graz, Austria), S. Albrecht (Institute for High Frequency Technique, Ruhr - University Bochum, FRG), W. Macher and M.T. Kiendl (Space Research Institute, Halbaerthgasse 1, A-8010 Graz, Austria)

Any antenna system aboard a spacecraft is strongly influenced by the conducting structure of the spacecraft body, thus the effective antenna length vectors responsible for the reception properties significantly deviate from the physical antenna rods. In the case of the Cassini/Huygens spacecraft configuration numerical simulations have been performed in order to analyse the electrical conditions of the Radio and Plasma Wave Science (RPWS) experiment. Main purpose of these studies is the improvement of the direction finding capabilities of the RPWS instrument.
After a short introduction of the Integral Equation Method results will be discussed on the basis of a wire-grid model with different levels of detailled spacecraft design. Finally, the implication of the findings with regard to the calibration of the antenna system by means of known radio sources (e.g. the Jovian Hectometer radio component during the Cassini fly-by at Jupiter) and the study of the Saturnian radio emission (SKR) will be outlined.

ON THE FEATURES OF FARADAY ROTATION OF DECAMETRIC RADIO EMISSION IN THE JOVIAN MAGNETOSPHERE

V.E. Shaposhnikov, V.V. Zaitsev (Institute of Applied Physics, Ulyanov Str. 46, 603600 Nizhny Novgorod, Russia)
M.Y. Boudjada, and H.O. Rucker (Space Research Institute, Halbaerthgasse 1, A-8010 Graz, Austria)
M. Aubier (Observatoire de Meudon, F-92192 Meudon, France)

We investigate the effect of Faraday rotation (FR) of decametric radio emission polarization in the Jovian magnetosphere (JM) taking into account the fact that position of the emission sources depends on emission frequency f. As a result we have a difference between emission ray paths in JM for different frequencies f, as well as a frequency dependence of the plasma density and magnetic field in the Appleton-Hartree equation. Thus, the traditional approximations of the amount of FR (Ω) by $\Omega = C_2/f^2$ or $\Omega = C_2/f^2 + C_4/f^4$ do not describe the effect of FR in the Jovian magnetosphere. For this aim the approximation $\Omega = C_0 + C_1/f + C_2/f^2$ can be used, where C_0 and C_1 characterize inhomogeneity of JM plasma across the emission ray paths. This formula gives us a possibility to separate contribution in the amount of FR from the Earth's ionosphere and the Jovian magnetosphere and to get information about JM due to ground-base FR observations. Moreover, it allows us to point out a reason of systematic error in qestimation by FR of the polarization position angle in the emission source. We also consider the Faraday rotation in the Io plasma torus, described by plasma model of Divine and Garret, to illustrate our results.

THEORETICAL MODELS OF $2f_{ce}$ AND $3f_{ce}$ AURORAL RADIO EMISSIONS OBSERVED ON THE GROUND

P.H. Yoon, A.T. Weatherwax and T.J. Rosenberg (all at Institute for Physical Science and Technology, University of Maryland, College Park, Maryland 20742, U.S.A.)
J. LaBelle and S. Shepherd (Department of Physics and Astronomy, Dartmouth College, Hanover, New Hampshire 03755, U.S.A.)

Naturally occurring radio emissions at 1 — 4 MHz that have been observed with ground-based instruments in the auroral zone include broadband, often bursty emissions (MF bursts), and narrow-band emissions (auroral roars) that are interpreted as emissions near the second and third harmonics of the ionospheric electron cyclotron frequency, f_{ce}. At present no satisfactory explanation for MF bursts is available. For the roar emissions, on the other hand, two categories of generation mechanisms have been proposed. In the indirect mechanism, auroral electrons excite electrostatic waves which then convert (by either linear or nonlinear process) to electromagnetic waves that propagate to the ground. In the direct mechanism, free space electromagnetic modes at 2 or $3f_{ce}$ are directly excited by auroral electrons through a process similar to the cyclotron maser emissions in the case of Auroral Kilometric Radiation (AKR). The recent theoretical advances made by the present authors regarding these mechanisms will be presented.

PS9 From laboratory studies to future space experiments

Convener: Ehrenfreund, P.
Co-Conveners: Kochan, H.; Krafft, C.; Pirronello, V.

Sponsorship: DLR, SRON

Reflectance Spectroscopy of Palagonites, Aluminous Phyllosilicates and Ferric Oxides as Analog Materials for Martian Bright Soil.

G. Arnold (Institut für Planetenerkundung, DLR Forschungszentrum Berlin-Adlershof, Rudower Chaussee 5, 12484 Berlin)

Visible and near infrared reflectance spectra of mixtures containing Hawaiian palagonitic soils, aluminous phyllosilicates and ferric oxides have been studied in order to evaluate the spectral properties of bright regions on Mars. Reflectance spectra of bright Martian soil exhibit an absorption band near 2.2 µm indicating a small content of crystalline aluminous clays. In order to simulate the appearance of the 2.2-µm band, diffuse reflectance spectra of mixtures with various wt-% of the components were measured. The 2.2-µm absorption band is discernible in these ternary mixtures with a depth of 1% in spectral contrast if the content of phyllosilicates increases up to 10-20 wt-%. These spectral analyses imply that the presence of comparable concentrations of crystalline aluminous clays can not be excluded in the bright regions of Mars.

LABORATORY DEVELOPMENT OF THE MUPUS COMPTON BACKSCATTER DENSITOMETER FOR THE ROLAND COMET LANDER

Ball, A J (Unit for Space Sciences and Astrophysics, University of Kent, Canterbury, U K) and Trow, M.W. (Mullard Space Science Laboratory, Holmbury St. Mary, Dorking, U.K) Smith, A. (Mullard Space Science Laboratory, Holmbury St. Mary, Dorking, U.K.) and Zarnecki, J.C. (Unit for Space Sciences and Astrophysics, University of Kent, Canterbury, U.K.)

The MUPUS physical properties experiment has been tentatively selected for the payload of RoLand, the lander to be deployed to the surface of comet P/Wirtanen as part of the Rosetta mission. One of the constituent instruments of MUPUS is a Compton Backscatter Densitometer. This will measure the bulk density of cometary material at the surface of the nucleus The technique involves injecting hard X-ray or gamma ray photons into the material and measuring the count rate of photons at the surface which have undergone Compton scattering in the bulk material. Such backscatter densitometers have been in use for terrestrial applications since the early 1950s and have been used by the Soviet Union on the Moon (Luna 13) and Venus (Veneras 9 and 10). The MUPUS densitometer will be incorporated into the MUPUS thermal probe, to be inserted into the nucleus surface. Results of laboratory experiments and theoretical calculations intended to determine the main design parameters and instrument characteristics are presented. CdTe detector technology has been studied as an alternative to the previously used Geiger tubes, and Am-241 has been considered as an alternative photon source to Cs-137, in order to reduce the demand for payload resources.

PRE-PLANETARY DUST EXPERIMENTS - PAST, PRESENT, AND FUTURE

J. Blum (Astrophysikalisches Institut und Universitätssternwarte, Friedrich-Schiller-Universität Jena, Schillergäßchen 3, D-07745 Jena, Germany)

We have performed simulation experiments on the collisional, sticking, and aggregation behavior of pre-planetary dust grains under solar nebula conditions, i.e. in rarefied gases and partly in a microgravity environment. These experiments simulate the physical conditions during the very first stages of planetesimal accumulation which were caused by mutual collisions between the dust aggregates due to Brownian motion and gas drag-induced sedimentation. The results of these investigations show that during the initial (low velocity) aggregation phase the growing dust clusters have fractal structures. At a later phase of aggregation, i.e. for larger aggregates and at higher impact speeds, the dust agglomerates may be compacted or restructured. At even higher velocities, the simple surface force-induced sticking process is no longer sufficient to allow for further grain growth. New mechanisms, such as collision-induced grain charging, aerodynamic rebound or fragmentation-driven mass accretion might become the important processes for the later stages of planetesimal accumulation. First experimental hints in these directions have been collected in our laboratory. However, new dedicated experiments to investigate these so far unexplored processes are needed for the future

LABORATORY SIMULATION OF CARBON COMPOUNDS: WISHES, RESULTS AND OPEN PROBLEMS

L. Colangeli, Astronomical Observatory of Capodimonte, Via Moiariello 16, 80131 NAPOLI, Italy

In a time when it is widely accepted that dust in space changes its intimate nature through different evolutionary phases, as long as it is present in various cosmic environments, understanding the properties of "laboratory analogues" represents a fundamental step to be undertaken. In this context, systematic analyses have been performed at the Cosmic Physics Laboratory of Naples on soot particles, synthesised and processed under carefully controlled conditions. From the comparative analysis of the results obtained for different kinds of carbon samples, exposed to thermal annealing, UV irradiation, and ion bombardment, it is possible to build up an evolutionary framework linking structure and optical behaviour of grains. In particular, the size, arrangement and abundance of "graphite-like" sp^2 clusters forming the soot grains appear to be among the driving properties which control the spectral characteristics. Since this concept appears to be a sort of general rule for most of the carbon-based samples analysed in many laboratories, the possibility exists that similar behaviours are found in space environment, as a function of the astrophysical ambient. Many observational data, concerning the carbon-based component of cosmic dust, seem consistent with the laboratory findings. Several open questions remain, however, unsolved and wait for results from next generation of laboratory experiments.

APPLICATION OF LABORATORY RESULTS TO THE MODELLING OF MARTIAN SPECTRA

Maria I. Blecka (Space Research Centre, Remote Sensing Department, Bartycka 18A, 00-716 Warszawa, Poland)
C. Cecchi-Pastellini, L.Colangeli, E. Palomba (Astronomical Observatory of Capodimonte, Via Moiariello 16, 80131 Napoli, Italy)
E. Epifani, S.Fonti (University of Lecce, Department of Physics, via Arnesano 73100 Lecce, Italy)

Currently conducted studies on radiance of the atmosphere and the surface of Mars are presented. The goal of our modelling is to evaluate the intensity and the shape of the spectra of the atmosphere by including both gases and a significant fraction of dust particles. We have taken into consideration also various states of the Mars surface by using reflectance and emissivity spectra measured in the laboratory. As examples of dust constituents we considered in our calculations: Olivine, Pyroxene and Palagonite.The modelling was performed with the aid of a modified version of the MODTRAN code.

THE VLF EMISSIONS GENERATION BY ACTIVE PLASMA ANTENNA IN THE IONOSPHERE AND MAGNETOSPHERE

Yu.V. Chugunov, G.A. Markov (Institute of Applied Physics, Ulyanov Str. 46, 603600 Nizhny Novgorod, Russia)

In this paper the data of the rocket experiment and the modelling experiments in plasma chamber on studying the operation of an active plasma antenna formed in the ionosphere by the radio-frequency (rf) discharge with the use of on-board electromagnetic source are presented. In the rocket experiment rf signal of the pumping generator (power - 1 kW, frequency - 480 kHz) was modulated by the frequencies $f_1 = 240$ Hz and $f_2 = 120$ Hz according to a special cyclogram. The VLF signals received on the Earth surface were distinguished from the background noise by an increased noise level. The spectral analysis of these signals has shown the presence of narrow-band emissions with the frequencies f_1 and f_2. These emissions were accompanied by the presence of modulation satellites which indicated the amplitude modulation of received signals by the frequency $f \approx 2.6$ Hz and were observable in the form of a fading sequence during the time of ~ 4.5 min after switching off the pumping generator (generation of an "echo" signals at the modulation frequency and excitation of ionospheric Alfven resonator in the Pc range). In modelling experiments in a plasma chamber the modulation of the plasma-wave discharge was accompanied by the complicated dynamics of dicharge plasma, the excitation of fast electrons and ions as well as the strong diamagnetic signals from discharge plasma. This work has been partly supported by the Russian Foundation for Fundamental Research under the Grant N 96-02-16471-a.

LABORATORY PYROLYSIS OF TITAN'S AEROSOL ANALOGUES IN THE FRAME OF THE CASSINI-HUYGENS MISSION

D. COSCIA[1&2], P. COLL[1], M-C. GAZEAU[1], G. ISRAEL[2] & F. RAULIN[1] (1=LISA, Universités Paris 7, Paris 12 & C.N.R.S, C.M.C., 61 av. du Général de Gaulle, 94010 Créteil cedex, France / 2=Service d'Aéronomie du CNRS, BP 3, 91371 Verrières le Buisson, France)

The atmosphere of Titan -mainly made up of N_2 and CH_4, and including many organics- also contains *hazes and aerosol particles* which shroud the surface of the satellite and gives its reddish appearance.
To reproduce in the laboratory the photochemical synthesis of these aerosols at high altitudes, and to study their formation processes and composition, an « aerosol generator » was developed. Titan's aerosols were thus produced under conditions similar to Titan's atmosphere (cold plasma energy source, pressure < 3 mbar and temperature < 200 K).
So far, the available samples most representative of Titan's atmosphere have been analyzed using a specialized instrument, a prototype of the ACP experiment (PI : Guy Israel). The objective of the Aerosol Collector Pyrolyser (ACP) experiment which will be aboard the Huygens Probe is to analyse the chemical composition. We present here the new data we obtained

RESTRUCTURING OF DUST AGGREGATES

C. Dominik (Leiden Observatory, P.O. Box 9513, 2300RA Leiden, The Netherlands)
A.G.G.M. Tielens (NASA Ames Research Center, MS 245-3, Moffett Field, CA 94035, USA)

Dust aggregates play an important role during the formation of the planetes in our and probably also in other planetary systems. We have develloped a theoretical model for forces acting at the interface between dust grains in an aggregate, and applied this model to theoretical calculations of dust aggregation. Our results show that (1) Growth of dust aggregates from monomers leads to fluffy aggregates. (2) Collisions with other aggregates or with large grains may induce compaction. (3) The relative velocities in the solar nebula between small grains are to low to produce marked compaction as long as the aggregates are small.

ISO OBSERVATIONS OF INTERSTELLAR ICES AND IMPLICATIONS FOR COMETS

P.Ehrenfreund (Leiden Observatory, P.O. Box 9513, 2300 RA Leiden, The Netherlands)

The evolution of interstellar dust grains plays an active role in interstellar chemistry and determines solid state and gas phase abundances. During their lifetime dust grains cycle between dense and diffuse clouds and undergo considerable metamorphism. Comets are likely the least evolved bodies in the Solar System and comet nuclei may be a low density aggregate of interstellar dust. An important constrain for the origin and evolution of comets is to search for the presence of pre-solar ices and organics. To study volatiles and grains in the cometary coma is one of the future goals of the ROSETTA comet rendezvous mission. In comparison with new ISO data, laboratory studies on interstellar ice analogs are presented which reveal the composition and structure of ices in dense molecular clouds. The ubiquitous presence and high abundances of interstellar CO_2 ice is discussed in the cometary context as well as column densities of molecules such as H_2O, CH_4, H_2CO and OCS which provide important constraints for the origin of cometary ices and for cometary evolution.

SIMULATION PROCEDURES TO RETRIEVE ATMOSPHERIC PARAMETERS FROM A PFS EXPERIMENT ONBOARD A FUTURE MARS MISSION

R. Haus (DLR-Institut für Planetenerkundung, D-12484 Berlin, Germany)
D. Titov (Space Research Institute, Moscow 117810, Russia)

A radiative transfer simulation technique is described that will be applied to retrieve atmospheric parameters from the measured infrared signatures recorded by the Planetary Fourier Spectrometer (PFS) onboard a future Mars mission. A prestored set of absorption coefficients which is based on quasi-monochromatic line-by-line calculations is used to predict the transmission functions for CO_2, CO and H_2O at 2.0 cm^{-1} resolution in a layered atmosphere. Synthetic spectra of the Martian emergent radiance have been calculated in the 200-8000 cm^{-1} wavenumber range (1.25-25 μm) for a variety of atmospheric models including the surface contribution. The influence of multiple scattering by different types of aerosols on radiative transfer is investigated on the basis of a successive order technique. Retrieval procedures and theoretical results for temperature profiles will be discussed.

SPACE TETHER SYSTEM FOR PLASMA BOUNDARIES LOCATION

F.Doudkin, V.Korepanov (Lviv Centre of Institute of Space Research, Naukova str., 5-A, 290601. Lviv, Ukraine)
S Klimov (Space Research Institute. Profsoyuznaya str.,84/32, 117810, Moscow, Russia)

Large-scale electromagnetic (EM) sounding of outer regions of the Earth's magnetosphere is a new exciting possibility to learn much about its global evolution and fundamentals of solar-terrestrial interactions. This problem has some specifics connected with the remote location of low density plasma boundaries which can be realized only with the help of spacecrafts and antennae of relatively great size. Also high sensitivity on-board complex for signals transmission/reception and rather complicated data processing has to be developed. A new methodology and hardware implementation for such kind of EM sounding realization is proposed. It consists of tether system, including one satellite and three subsatellites, connected with rope. Preliminary calculations show that with the help of sectionned antennae from non-magnetic steel rope about 2,4 km long and 4 mm in diameter it is possible to provide reliable sounding of the main bow shock at the distancies up to 30 Earth's radii when the electron concentration of the solar wind (about 1-100 particles per cm^3) changes 3-5 times.

VARIATION OF THE SPECTRAL CHARACTERISTICS OF MASSIVE PYROXENE AND BASALT SAMPLES IN THE NEAR-INFRARED DUE TO VARYING SURFACE ROUGHNESS

J. Harloff and G.Arnold (DLR, German Aerospace Research Establishment, Institute of Planetary Exploration, Rudower Chaussee 5, 12489 Berlin, Germany)

Except for a few noticeable exceptions, most of the reflectance spectroscopy investigations of planetary analog materials have so far been done with powdered samples. Nevertheless, it is a known fact that there are differences in the spectral characteristics of a massive surface and a powder of the same sample, and that the spectral features of a massive sample change with the surface roughness. The lack of extensive studies of these dependences might give rise to problems when trying to interpret remote sensing data from planetary features that are not covered by regolith, i.e. where outcropping rock is directly visible. In this study, powders and slabs of the same mineral and rock specimens were prepared (three different pyroxenes and three different basalts, whose mineralogy and chemistry were characterized by polarization microscopy of thin sections and X-ray fluorescence analysis). Of all samples, reflectance spectra were recorded in the near-infrared (in the wavelength region of 0.5 to 5 μm), to compare the differences in the spectral characteristics of the powders and the slabs. Furthermore, the roughness of the slabs was systematically altered by grinding and polishing, in order to investigate the dependence of the spectral features on the condition of the surface. The degree of roughness was characterized by direct-light microscopy and by means of an electrical contact (stylus) instrument, a technique commonly used in engineering sciences to quantitatively measure roughness values of technical surfaces.

PRE-PLANETARY SEDIMENTATION-INDUCED GRAIN GROWTH - A NEW EXPERIMENTAL APPROACH

L.-O. Heim, G.Wurm, and J. Blum (Astrophysikalisches Institut und Universitätssternwarte, Friedrich-Schiller-Universität Jena, Schillergäßchen 3,D-07745 Jena, Germany)

The process of star formation leads to an accretion disk of gas and dust around the dense proto-star object in the center. Caused by Brownian motion, sedimentation processes, and gas turbulence, impacts between the dust particles are frequently occuring. This initiates a process which can lead to planets or planetary systems around the young star. The formation of planets can be subdivided into two main sequences: (1) coagulation of particles induced by impacts and adhesion forces, (2) gravitation-induced accretion of extraneous matter. To get more information about the first process, experiments can be done with analog particles, modeling the dust grains in the pre-planetary accretion disk. One way to do so is under micro-gravity conditions in drop towers, parabolic aircraft flights or in space experiments. A new possibility will be introduced: We use a levitation technique witch allows us to get insight into the coagulation process of micron-sized particles in thin gas atmospheres comparable to the conditions in the pre-planetary accretion disk. With this experiment, it is possible to observe the aggregate growth process for time spans longer than ten minutes in the laboratory which yields useful information about the size distributions and structures of the agglomerates. The technique and first results of our simulation experiment will be presented.

LABORATORY STUDIES OF CARBON DUST ANALOGUES

Th. Henning (Astrophysical Institute and University Observatory, Schillergäßchen 3, D-07745 Jena, Germany)
C. Jäger (Astrophysical Institute and University Observatory Jena)
H. Mutschke (Astrophysical Institute and University Observatory Jena)
M Schnaiter (Astrophysical Institute and University Observatory Jena)

This contribution will summarize recent research on carbonaceous cosmic dust analogues. We start with a general description of the different structural forms of soot particles and discuss the main observational facts related to the solid carbon component in space.
For the first time, we produced isolated nanoparticles composed of carbon by a molecular beam technique. As source we used both a flame and resistively heated rods. These particles were spectroscopically characterized by matrix isolation spectroscopy. Depending on the state of graphitization, a narrowing of the electronic π-π^* transition could be observed
In addition, we investigated the relation between the optical properties of the grains and their structure. This structure was characterized by electron microscopy, electron energy loss spectroscopy, Raman spectroscopy, and ^{13}C NMR. The optical properties in the UV/VIS and IR region are mainly determined by the hybridization state, the crystallite sizes, and the state of order. One has to distinguish between really plane graphite crystallites and bent graphene layers because these layers have a lower electron density.

MEASUREMENTS OF OPTICAL CONSTANTS AND GRAIN SIZE INFLUENCE ON THE SPECTRAL FEATURES OF QUARTZ. APPLICATIONS FOR PLANETARY REMOTE SENSING

K. U. Junghans, G. Arnold and J. L. Bishop (Institut fuer Planetenerkundung, DLR, Rudower Chaussee 5, 12489 Berlin, Germany)

The infrared reflectance and emittance spectra of mineral samples include information about the mineral composition, sample texture and particle size. The optical constants (n and k) of alpha-quartz have been measured by ellipsometry and compared to literature values determined using dispersion analysis. Mie-theory allows us to calculate the absorption, scattering and extinction efficiencies and the single scattering albedo of a spherical particle in dependence of the optical constants n and k and the size parameter. Following Conel's work (1969) we have defined 4 different cases of spectral behavior at different wavelength positions: a) n=1, k is small, b) n<1, k small c) n and k undergoes rapid change (anormal dispersion), d) n>1, k small. A comparison of reflectance, emittance and single scattering albedo has been performed at these 4 wavelength positions for different grain sizes. Planetary regoliths consist of materials with a range of grain sizes often including a large proportion less than 100 µm. Therefore, for the evaluation of future planetary remote sensing data it is important to understand the influence of grain size on the spectral signatures of minerals and soils.

Physical aspects of the seismic research of the terrestrial planets

O.B. Khavroshkin, V.V. Tsyplakov

The precise metrological systems and experimental installations to carry out fundamental physical investigations that operate at the limited sensitivity and also a problem of a flicker-noise (noise 1/f) as a laboratory factor required a complex analysis and evalution of a part a final stage of interpretation of the observed date. It becames evident that these fundamental experiments to for searching gravitationel waves and similar them should be carried out according to scheme of the coinsidences the Earth and another celestial bodies (Mars,Moon).

Inversion of CONSERT simulated data : a statistical characterisation of the comet nucleus

A. Herique, W. Kofman

The CONSERT experiment for the ROSETTA mission will scan the internal structures of the comet nucleus. To validate scientific goals and instrument design, we develop statistical inversion method and test it on simulated data. All aspects of this work are presented in this paper. We first present the used analytical model of nucleus permittivity, defined by a mean permittivity plus perturbations. We use the WKB approximation of the rays propagation to simulate 90 MHz radiowave transmission from the Lander to the Orbiter through the cometary body. We also discuss a new frequency propagation technique to back-propagate the simulated signal from the orbit to the nucleus surface. This is necessary to interpret the data correctly and also to increase the SNR. After back-propagation, we estimate the mean permittivity along each path. This mean permittivity for each measurement point of the orbit characterises the large scale nucleus structures. Then we show that the signal is not stationary. We set out a new method, similar to time frequency analysis, to calculate the correlation length of small scale inhomogeneities of the nucleus (<300m). To conclude, we present the method robustness.

Cometary Surface Properties derived from Sensors at the Anchor of a Comet Lander

G. Kargl, N. I. Kömle, M. Dziruni and A. Ball

Due to the ROSETTA mission and the planed in situ investigation of the landing vehicle RoLand, the surface properties of comets have become a new focus of research. The estimated low gravity makes it necessary to anchor the lander immediately after touchdown to prevent a rebound from the surface and to allow movements of mechanical devices during measurements. On the other hand the anchoring device is probably that part of the lander which is probing into deeper layers than any other instrument. Therefore the anchor is equipped with an accelerometer and a temperature sensor. By measuring the deceleration history of the anchoring event the tensile strength of the penetrated layers could be derived. The temperature sensor would provide a useful addition to the grid of temperature measurements taken by other instruments of the ROSETTA mission We report here about experiments made with the preliminary design of the RoLand anchor and the interpretation of the results with respect to an improved understanding of cometary surface layers and related processes.

DEVELOPMENT OF A SMALL SAMPLING SYSTEM FOR SPACE MISSION APPLICATIONS TO MARS, MOON , AND COMETS

H. Kochan (DLR, Institute for Space Simulation, D - 51140 Koeln, FRG)
E. Re, D. Hazan (Tecnospazio S.p.A., Via Mercantesse 5, 20021 Baranzate di Bollate (MI), Italy)
A. Nista (Tecnomare S.p.A., 30124 Venezia, San Marco 3584, Italy)
A. Brighenti (Systems & Advanced Technologies Engineering, 30124 Venezia, Italy)
P. Coste (ESA/ESTEC, Structures and Mechanisms Division (YMM), Keplerlaan 1, P.O. Box 299, NL 2200 AG Noordwijk - The Netherlands)
J. Vidquist, T. Ylikorpi (VTT Automation Space Technology, Metallimiehenkuja 8, P.O.BOX 1303 FIN - 02044 VTT, Finland)

As first results of an ESA technology-study, the selection and tests of drill bits for applications in simulated cometary, Lunar or even Martian sample material will be reported. The so called cheese scraper drill bit was tested in olivine dust, quartz sand and in gas-concrete, the latter under normal and LN2 - temperature (77K). Also the sampling in porous ice material was examined. In any case the drill-bit successfully sampled enough material for a further optical (telemicroscope) or gaschromatographic investigation as planned during the ROSETTA Lander investigations of a cometary surface. In a second part the presentation will cover the test results of the breadboard model of the sampling system. The breadboard will consist of the support structure, and the three units: The Sampling Units (drill bits); The Handling and Transportation Unit, A simulated Oven (EGA-experiment) with a docking adapter, In addition the support structure in corporates the sample containers.

DEVELOPMENT OF A SMALL "MOBILE PENETROMETER" FOR SPACE MISSION APPLICATIONS TO MARS, MOON, AND COMETS

H. Kochan (DLR, Institute for Space Simulation, D - 51140 Koeln, FRG)
V.V.Gromov, S. Matrossov, A.V. Mitskevitch, E.N.Yudkin (VNIITRANSMASH, Zarechnaja Street 2, 198323, St.-Petersburg, Russia)
P. Coste (ESA/ESTEC, Structures and Mechanisms Division (YMM), Keplerlaan 1, P.O. Box 299, NL 2200 AG Noordwijk - The Netherlands)
E. Re, D. Hazan (Tecnospazio S.p.A., 20021 Baranzate di Bollate (MI), Italy)

Within an ESA technology-study, a "mobile penetrometer", a small cylindrical body, 2cm in diameter and around 32cm in length, was developed for space mission applications from the Russian team in St. Petersburg. The intrusion of the prototype system was successfully tested in DLR horizontally under simulated microgravity conditions with aid of an easy going railroad car as carrier. The experiments were performed under normal environmental conditions in quartz sand. The operational performance in general and the test data will be reported in here.

The CONSERT experiment for the ROSETTA mission

W.Kofman and Y.Barbin, J.Klinger, A-C.Levasseur-Regourd, J-P.Barriot, A.Herique (FRANCE); T.Hagfors, E.Nielsen, E.Gruen, P.Edenhofer, H.Kochan (GERMANY); G.Picardi, R.Seu, (ITALIE); J.van Zyl, Ch.Elachi, J.Melosh, J.Veverka, P.Weissman (UNITED-STATES); L.H.Svedhem (ESA); S.E.Hamran (NORWAY); I.P.Williams (UNITED KINGDOM)

CONSERT is a radio propagation experiment on the ROSETTA mission to explore the interior of the comet. The cometary material has an average dielectric constant somewhat between 1 and 3 and probably very low losses for the frequency range between a few MHz to about 200 MHz. This allows to use the electromagnetic waves in order to scan the interior of the comet, using the propagation between the Lander and the Orbiter. The received signal will contain, in the group delay and amplitude, information about the average dielectric constant along the given propagation path, irregularities and the structures inside the comet. From these measurements, information about the materials will be derived. On some chosen examples, we describe the simulation of the experiment. The technical description will also be made.

LABORATORY MODELING AND THEORY OF THE RADIATION AND PROPAGATION OF WHISTLER WAVES IN MAGNETOPLASMAS

A.V. Kostrov and T.M. Zaboronkova (Institute of Applied Physics RAS, Ulyanov str. 46, Nizhny Novgorod, 603600, Russia)

The paper reviews the results of studies of the electrodynamic characteristics of VLF dipole and loop antennas locating in magnetoplasma. Our research has been focused on the investigation of radiation pattern and space-time structure of the field, the propagation of e.m. waves in inhomogeneous plasma, and the influence of plasma nonlinearities on the radiation of VLF antennas. The role of different parts of the spatial spectrum of the whistler waves excited by antennas in the formation of the structure of the electromagnetic field has been studied in the case of unperturbed magnetoplasma. The influence of various factors (geometrical size of antennas, plasma density, etc.) on the radiation efficiency has been analysed. A detailed study of the problem of VLF antenna radiation in the present of artificial plasma density ducts has been carried out. Excitation and propagation of guided whistler waves and their reradiation into the surrounding plasma have been investigated theoretically for the cases of low-density, higher-density and nonmonotonous distribution density channels including the case of "narrow" ducts. The peculiarities of whistler wave emissions in the presence of plasma nonlinearities have been studied. The change of the antenna impedance under the action of the additional powerful pulse has been investigated and the possibility to improve antenna matching by varying the antenna impedance has been shown.

INFLUENCE OF NONLINEAR EFFECTS ON THE ELECTRODYNAMIC CHARACTERISTICS OF VLF LOOP ANTENNAS IN MAGNETOPLASMA

A.V. Kostrov and A.V. Kudrin, A.A. Shaikin, A.I. Smirnov, M.V. Starodubtsev, T.M. Zaboronkova (Institute of Applied Physics RAS, Ulyanov str. 46, Nizhny Novgorod, 603600, Russia)

This paper deals with experimental and theoretical investigations of the influence of plasma nonlinearities on whistler wave emissions from loop radiators when the antenna is immersed in a primarily unperturbed magnetoplasma. Our experiments have been carried out in the large plasma device "Ionosphere". In the experiments, a transmitting antenna was continuously fed with an operating small-amplitude signal. Simultaneously, the antenna was supplied with an additional strong electromagnetic pulse. The pulsed signal caused the thermal-diffusion redistribution of the plasma in the antenna vicinity that, intern. led to the formation of a field aligned density channels. The transverse and longitudinal field distributions in the duct were studied in a wide range of variations of plasma density. Besides, the strong pulse has created the intensive near field whose ponderomotive force moved the plasma away from the antenna surface and consequently the antenna input impedance has changed. In conclusion we note, that our experimental result have confirmed that the input impedance of loop antenna and the current distribution in it are significantly dependent on the parameters of the double layer near the antenna surface. Also, nonlinear effects in the double layer lead to the generation of the VLF waves at the harmonics and the combination frequencies of the signals fed to the antenna.

WAVE EMISSION FROM AN ELECTRON BEAM INJECTED IN A MAGNETIZED PLASMA

C. Krafft (Laboratoire de Physique des Gaz et des Plasmas, B=83t.210, Universit=82 Paris Sud, 91405 Orsay Cedex, France)

Experimental and theoretical investigations have been performed to study the interaction of an electron beam with a magnetized plasma, for the conditions of active space experiments injecting=20 artificial beams in the Earth ionosphere as well=20 as for the case of overdense laboratory plasmas or natural beams in the Earth magnetosphere. The structures of the electromagnetic fields far and near the beam, the dispersive properties of the radiated whistler waves, the efficiency of the beam modulation, the development of beam instabilities, the power emitted by the beam and the coherence level=20 of the emission process, as well as the conditions=20 for an undistorted registration of the whistler=20 signals by remote receivers in space have been examined=20 through laboratory measurements, numerical simulations and=20 theoretical analysis.

SOUND PROPAGATION EXPERIMENTS IN GRANULAR MEDIA IN PREPARATION OF THE ROSETTA LANDER'S CASSE EXPERIMENT

M. Kretschmer, H. Kochan, D. Möhlmann (DLR - Institute of Space Simulation, Linder Höhe, D-51147 Cologne, Germany), W. Gebhardt (Fraunhofer Institut für zerstörungsfreie Prüfverfahren, D-66123 Saarbrücken)

The Cometary Acoustic Sounding and Seismic Experiment (CASSE, acoustic part (-AC)) aboard the Rosetta Lander will, once it had touched down onto the cometary surface, determine some of the surface regolith's elastic properties by measuring the sound propagation from foot to foot. In a further phase the acoustic transmitters and receivers, based on piezo technology, will be used as an 'acoustic radar' to give an impression of the structure of the subsurface layers and to determine the regolith layer thickness.
In preparation of CASSE-AC, laboratory experiments concerning the sound propagation in porous, loosly bound, and granular media, such as Cometary Analog Material (CAM, mineral dust and water ice sprayed into liquid nitrogen), ice, sand, pebbles and glass balls are described.
These measurements are compared to a theory of sound in granular media and accompanying computer simulations.
Also a status report of the experiment design of CASSE-AC will be given.

DEVELOPMENT OF THE DOUBLE FOCUSING MASS SPECTROMETER 'DFMS' FOR THE 'ROSETTA' COMET RENDEZVOUS MISSION

K. Lange, A. Schönemann, K. Altwegg, H. Balsiger, P. Eberhardt, J. Fischer, R. Häberli, and M. Steinacher (Physikalisches Institut, Universität Bern, Sidlerstr. 5, CH-3012 Bern, Switzerland)
E. Arijs (BIRA, Ringlaan 3, B-1180 Bruxelles, Belgique)
J.J. Berthelier (IPSL, F-94100 Saint-Maur, France)
T. Gombosi (University of Michigan, Space Physics Research Laboratory, An Arbor, Mi 48109, USA)
E. Shelley (Lockhead Palo Alto Research Laboratory, 3251 Hanover St., Palo Alto, CA 94304, USA)

The detailed investigation of the composition of the cometary atmosphere and ionosphere is widely accepted to play a key role with respect to the main objectives of the Rosetta comet rendezvous mission. To fulfill the demanding objectives, the three sensor instrument package ROSINA (Rosetta Orbiter Spectrometer for Ion and Neutral Analysis) was proposed. The DFMS (Double Focusing Mass Spectrometer) was especially developed to measure the elemental and molecular abundances as well as the isotopic composition providing a very high mass resolution and a large dynamic detection range for masses up to about 100 amu.
Subsequent to the description of the design and characteristics of this magnetic sector spectrometer, the experimental performance of the first laboratory prototype will be described. Using an external N_2^+ ion beam and a channeltron mounted on a movable table as detector, a mass resolution of up to about 2000 at 1 % peak height was already obtained.

CHEMISTRY FOR ROSETTA : PURIFICATION OF CO_2 FROM A OF COMETARY-LIKE MIXTURE USING GROUP II OXIDES.

C. Lécluse & F. Robert (Muséum National d'Histoire Naturelle, Laboratoire de Minéralogie, URA n° 736, 61 Rue Buffon, 75005 Paris, France).

In 2011, the Rosetta spacecraft will reach the Comet Wirtanen for a precise investigation of its physical and chemical properties. Species like H_2O, CO, CO_2, CH_4, NH_3 HCN and organic molecules have been already determined in Comet Halley and Giacobini-Zinner. CO_2 is of particular importance because it is one of the most abundant carbon bearing molecule. Nevertheless abundance and isotopic composition of the main species remain uncertain. Aboard the spacecraft, the determination of the chemical composition of the majors compounds will be run with a gas chromatograph linked to a mass spectrometer. Their precise isotopic composition will be determined by mass spectrometry, after an additional chemical purification.
The results of the investigation of the purification of CO_2 from a cometary-like mixture in laboratory will be presented here. Group II oxides (MgO, CaO and BaO) were chosen because of their reactivity towards CO_2. The dependence in temperature of the efficiency of the purification of CO_2 from a cometary-like mixture in the presence of different group II oxides will be shown as well as the isotopic fractionation. From this study, a sequence of purification of CO_2 from cometary-like mixture will propose in the context of the Rosetta mission.

LIGHT SCATTERING EXPERIMENTS IN MICROGRAVITY

A.Ch. Levasseur-Regourd (Université Paris VI / Aéronomie CNRS, BP 3, 91371, Verrières, France)

The solar light scattered by dust particles in the Solar System depends upon the physical properties of the dust. The particles are unfortunately irregular aggregates whose scattering properties cannot be adequately described by simple models. Besides, laboratory measurements conducted on the Earth are biased by sedimentation or levitation. This is the reason why microgravity is an appropriate tool for experiments on samples representative of space conditions.
The observed scattering functions will be reviewed, together with the limits of the computational approaches and the results of some Earth based laboratory measurements. Then, the principle and the results of the PROGRA^2 experiment during parabolic flights, a first and successful step towards measurements under microgravity, will be summarized. Finally, the scientific rationale and the principle of the CODAG-LSE and OPAL experiments, two light scattering experiments which should take place respectively during a rocket flight for aggregates of spheres (April 1998) and on board a space station for various samples covering a wide range of physical properties, will be presented.
PROGRA^2 and CODAG are funded by CNES and by ESA.

REFLECTANCE SPECTROSCOPY OF NATURAL SOLID BITUMENS AS ANALOGS OF COMETARY AND ASTEROID ORGANIC MATERIALS

L.V. Moroz, G. Arnold, R. Wäsch (DLR Institut für Planetenerkundung, Rudower Chaussee 5, D-12484 Berlin, Germany) and A. Korochantsev (Vernadsky Institute, Kosygin 19, 117975 Moscow, Russia)

One of the main goals of „Rosetta" mission will be the study of the cometary nucleus. The observations of P/Halley have shown that cometary nucleus is heterogeneous and consists of bright and dark materials. Brighter components could be interpreted as ices, while darker materials are represented by the assemblages composed of refractory organics and inorganics. The composition of organic components of primitive meteorites and IDPs, infrared observations of comets and the mass-spectrometry of P/Halley CHON particles suggest that cometary refractory organics probably consist mainly of complex mixture of various hydrocarbon polymers. To interpret the spectral properties of cometary surface one needs to have spectral library of the relevant organic materials. For this purpose we performed the spectral reflectance measurements of natural solid oil bitumens (asphaltites, kerites, anthraxolites) in the range of 0.5-16 μm. These dark solids are complex mixtures of organic compounds, most of which are aliphatic and polycyclic aromatic hydrocarbons. The samples were characterized by chemical analyses, solid-state ^{13}C-NMR, and X-ray diffractometry. In the NIR region the spectral parameters have been found, which make it possible to spectrally derive aromaticities (f_a) and H/C ratios. The studies of how the admixtures of various relevant minerals (anhydrous and hydrated silicates) may affect these spectral parameters are in progress.

LINE SHAPE STUDIES OF THE INFRARED SPECTRAL LINES OF $^{14}NH_3$ AND $^{15}NH_3$ APPLICABLE TO THE JOVIAN ATMOSPHERE.

V. Nemtchinov and P. Varanasi (Institute for Terrestrial and Planetary Atmospheres, The University at Stony Brook, NY 11794-5000, U.S.A.)

Spectroscopic observations of Jupiter in the 10 μm region are influenced by the absorption lines of $^{14}NH_3$ and $^{15}NH_3$. In order to aid the planetary astronomers we have performed extensive measurements in our laboratory on several H_2-broadened and self-broadened lines in the ν_2-fundamental bands of $^{14}NH_3$ and $^{15}NH_3$ at conditions representing those of the Jovian atmosphere. We present line intensity and line width data obtained at 200, 255, and 295 K. From these data we have deduced the temperature dependence of the linewidths as a function of the rotational quantum numbers J and K. We also present an analysis of the appropriate lineshape that is relevant to the planetary atmospheric observations. The data are useful not only in the analyses of the $^{14}NH_3$ and $^{15}NH_3$ lines in the planetary spectra but also in determining the influence of the trough absorption of ammonia lines on the overlapping lines of other molecular species.

REFLECTANCE STUDIES OF MARTIAN ANALOGUE MATERIALS

E. Palomba, C. Cecchi-Pestellini, F. Esposito, L. Colangeli, Astronomical Observatory of Capodimonte, Via Moiariello 16, 80131 NAPOLI, Italy

Starting from the last year, several space missions have been launched/planned to explore the planet Mars. In this perspective, laboratory investigation on Martian analogue samples becomes a powerful tool to interpret correctly data already available from past exploration and to be returned from future observations. In the present paper, we report the results of analyses performed on typical Martian soil and aerosol constituents, which have been characterised spectroscopically in the near and medium IR. Reflectance spectra have been measured in two differet modes of operation: specular, with a 45 deg incidence angle, and diffuse biconical. Spectra in specular mode are obtained on pressed pellets, with smooth surface, of the examined samples. Optical constants, n and k, can be retrieved from these measurements. Particulate samples, of the same materials, with calibrated grain sizes, are characterised in diffuse reflectance, to simulate the Martian regolith. From diffuse refle tance data the emissivity of the materials can be retrieved via the Kirchoff law. Refraction indices and emissivity data, for samples relevant to reproduce martian materials, are needed as input to models aimed at simulating radiation transfer in the planet atmosphere taking into proper account emitted, reflected and scattered contributions from the solid component.

CO_2 PRODUCED BY ION IRRADIATION OF ICES

M.E. Palumbo, G.A. Baratta, A.C. Castorina G. Strazzulla (Osservatorio Astrofisico, V.le A. Doria 6, I-95125 Catania, Italy)
J.R. Brucato, (Osservatorio Astronomico, Napoli, Italy)
M.A. Satorre (Departimento Fisica Aplicada EPSA, Esquela Politecnica Superior Alcoi, Alicante, Spain)

Ion irradiation of ice mixtures produces several effects among which the production of other species not present in the original target. We have studied, by infrared absorption spectroscopy, the formation of carbon dioxide (CO_2) after ion irradiation (3 to 30 keV) of astrophysically relevant ice mixtures containing CO, H_2O, CH_3OH, CH_4, NH_3. Laboratory experiments have shown that the profile (shape, width and peak position) of the IR bands is strongly affected by irradiation processing as well as thermal history and the matrix in which each species is embedded in. These results are used to understand the chemical and physical characteristics of ices in space. Furthermore, experiments have been conducted to measure optical constants (n and k values) of the ices, that are important when comparisons with astronomical spectra are performed.

FORMATION RATE OF MOLECULAR HYDROGEN ON SILICATE SURFACES AT INTERSTELLAR TEMPERATURES

V. Pirronello (Istituto di Fisica, Universita' di Catania, Catania, Sicily, Italy)
Chi Liu, Liyong Shen and G. Vidali (Department of Physics, Syracuse University, Syracuse, NY, USA)

Molecular hydrogen is certainly the most important molecule in the interstellar medium because it is the most abundant and because, when ionized by UV photons or cosmic rays, it enters in all gas phase reaction schemes triggering the synthesis of more complex species. We report on the experimental results on the recombination rate of hydrogen obtained for the first time on a natural silicate (olivine) that, even if polycrystalline and not amorphous, can be regarded as the closest analogue to interstellar silicates used up to now with this aim. Our measurements give considerably lower values for the recombination efficiency (sticking probability times the probability of recombination upon H-H encounter) than model-based calculations, at least at the temperature of interstellar grains. In order to reconcile our experimental results with observational estimates of the rate of formation of molecular hydrogen we suggest that the actual surface of dust grains is rougher and its area larger than considered in models. Theoretical calculation should then consider amorphous rather then crystalline surfaces because its morphology should influence strongly both sticking and tunneling processes; it is, in fact, reasonable to assume that sticking will be higher and diffusion length will be lower on amorphous than on crystalline grains.

LABORATORY EXPERIMENTS FOR THE ANALYSIS OF TRITON SPECTRA

E. Quirico and **E. Quirico** (Laboratoire de Géophysique et Planétologie, 44072 Nantes, France)
S. Douté (LGGE-CNRS, F-38402 Saint Martin d'Hères, France)
B. Schmitt (LGGE-CNRS, F-38402 Saint Martin d'Hères, France)
C. de Bergh (DESPA, Obs. Paris-Meudon, F-92195 Meudon, France)
D. P. Cruikshank (NASA-ARC, Moffett field 94035, CA, USA)
T. C. Owen (IFA, Univ. of Hawaii, Honolulu 96822, HI, USA)

We present some laboratory studies on the N_2:CH_4 and N_2:CO mixtures and their application to the analysis of near-infrared observations of the surface of Triton. Experiments were performed using samples produced via two different techniques: i) thin films, obtained from the condensation of gas on a cold window; ii) crystals grown from the liquid phase in a closed cryogenic cell. Our results show that the spectra are highly sensitive to the experimental conditions and to the formation technique of the sample. They call for taking care about the way experimental data are used to solve astrophysical problems. A systematic study of the effects of temperature and concentration allow us to identify useful indicators of the physical state of the ices present at the surface of Triton Finally, these experimental data are used simultaneously with a bidirectionnal reflectance modelling for the analysis of the near-infrared reflectance spectra of Triton

DYNAMICAL CONSTRAINTS TO THE MASSES OF LARGE PLANETESIMALS

M. G. Parisi and A. Brunini (Facultad de Ciencias Astronómicas y Geofísicas, Universidad Nacional de La Plata, La Plata, Argentina)

Recently, we have shown in a previous work (Symposium "From Stardust to Planetesimals": contributed papers) that a single, large impact of a body being 1-10 % of the planet final mass, at the end of the outer planets accretion process, excites orbital excentricities which are compatible with the present observed values. In this paper, we show that the impulse transfered to the planetary orbit through a single close encounter with these large bodies, is in agreement with the present orbital parameters. By a simple dynamical method, we estimate through this encounter the maximum allowed mass of the largest bodies at the end of the planets formation process, which are in good agreement with previous estimates. However, when the acummulative effect of close encounters with different masses during all the accretion process is considered, the resulting orbital eccentricities are higher than their present values. In this paper, we discuss this problem in the most general frame of the planetary perturbations arriving to a possible solution to this disagreement.

ON THE STICKINESS OF MICRON-SIZED DUST GRAINS

T. Poppe, L. Heim, and J. Blum (Astrophysikalisches Institut und Universitätssternwarte, Friedrich-Schiller-Universität Jena, Schillergäßchen 3, D-07745 Jena)

Micron-sized dust grains embedded in a dilute gas are regarded as the seeds of the planet formation in the solar nebula. Planetesimals and cometesimals form due to inelastic collisions between dust grains and due to van der Waals and other attractive surface forces, which determine physical processes such as coagulation, restructuring, compaction, and fragmentation. The low velocity collisions result from Brownian motion for the micron-sized pre-planetary dust particles and from differential sedimentation and gas drag-induced orbital decay for mm-sized dust aggregates, which are believed to be fluffy grains composed of the micron-sized particles. While the state of the gas disk and the motion of particles therin is comparatively well known, research on the collisional behaviour and the inter-particle forces is lacking. We present the techniques and results of two experimental approaches for determining the sticking properties of small dust grains. In one experiment, individual grain-target collisions are investigated to observe the velocity limit of sticking and collisional grain charging. In another experiment, the static attraction force between single particles is directly measured by the use of an atomic force microscope.

OBSERVATION OF DRIFT WAVE DESTABILISATION IN PLASMAS

C. Riccardi, L. Gamberale, L.Fattorini, C.Bevilacqua, G.Chiodini and M. Fontanesi (Dipartimento di Fisica, Universita' degli Studi di Milano, via Celoria 16, 20133 - Milano, Italy)

Our experiment concerns the analysis of the generation of turbulence starting from quasi-coherent drift modes and has been performed by evaluating wavenumber and frequency spectra and bicoherence coefficients of the density fluctuations related to the quadratic wave-wave interactions.
The experiment has been carried out in a toroidal device where it was possible to change the plasma parameters (electron density and toroidal magnetic field) over a wide range. By changing the toroidal magnetic field the kind of instability and the way in which the quasi-coherent modes destabilise until they generate turbulence has been analysed.
In low toroidal magnetic field regime (B<600 G) the statistical dispersion relation of drift waves driven by density gradient is clearly identified. The waves are spatially quasi-coherent (their coherence coefficient is about 0.99) and are not involved in the nonlinear interactions, being the bicoherence coefficient of the order of the statistical noise. At larger toroidal magnetic field (up to 2 kG) the destabilisation of drift modes takes place and turbulence develops. Spectra are characterised by a wide spread of wavevector values and low spatial coherence coefficient (γ is of order 0.2). In this regime bicoherence analysis shows a large presence of wave-wave coupling.

ORGANIC CHEMISTRY IN SPACE AND LABORATORY SIMULATION AS FOLLOWED BY THE ELEMENTARY RATIO INDICES METHOD (ERI)

K. Roessler (Institut für Nuklearchemie, Forschungszentrum Jülich GmbH, D-52425 Jülich, Germany)

The changes in concentration and composition of organic compounds by radiation belong to the most important issues of space chemistry beit in observation or laboratory simulation. A general method for comparing individual changes as well as group interactions in a closed system of e.g. a planetary atmosphere or a cometary nucleus had been developed for hydrocarbons [1]. The H/C elementary ratio was plotted against the number of carbon atoms, which resulted in a two-dimensional representation of the „Hydrocarbon World". A new system is presented here for all CHON compounds. The elementary ratio indices ERI: H/C, N/C and O/C are plotted three-dimensionally for all organic compounds. Reduction or oxidation processes can be followed by summing the ERI of the involved compounds weighted according to their concentration and number of carbon atoms. Other plots of only two indices against the number of carbon atoms per molecule allow a modified treatment of the reactions. The ERI-method is applied to radiation and suprathermal atom induced reactions in the atmosphere of Earth and Titan and cometary comae as well as in cometary nuclei, interstellar grains and upon bolide impact in observation and laboratory simulation. Circular reactions and restitution of equilibria as well as H-elimination, aromatic ring formation, oxidation or reduction can be followed. The ERI-method thus constitutes a unique tool for description of organic chemistry in space.

[1] K. Roessler, Nucl.Instr.Meth. **B65**, 55-66 (1992).

FORMALDEHYDE AND VISCOUS ORGANIC SUBSTANCES AS CRUST FORMING MATERIALS IN COMET SIMULATION EXPERIMENTS IN VIEW OF ROSETTA.

K. Roessler (Institut für Nuklearchemie, Forschungszentrum Jülich GmbH, D-52425 Jülich, Germany),
H. Kochan, D. Möhlmann, and K. J. Seidensticker (Institut für Raumsimulation, DLR-Köln, D-51440 Köln, Germany)

In the comet simulation experiment KOSI-11 [1] in the Big Space Simulator Chamber and a series of accompanying experiments in the Small Simulator Chamber of Institut für Raumsimulation of DLR-Köln the formation of organic crusts on cometary analogs was studied. To mixtures of ice, frozen CO_2, and minerals organic constituents were added such as sugars, polysaccharose, sirups, tar, tree seal, paraffins, other organic refractories and frozen formaldehyde. Crust formation was sometimes very dramatic, accompanied by gas eruption and the occasional formations of liquid phases on the surface.
Frozen CH_2O showed the best sealing effects polymerizing to polyoxymethylene and cyclic forms including small amounts of sugars. The crust was even thicker and stronger when basic constituents such as NH_3 were present. The addition of already polymerized material (polysaccharose, polyoxymethylene etc.) and kerogen did not result in gross changes of the surface upon artificial insolation. The experiments are aimed to check the formation mechanisms and potential strengths of cometary crusts in view of ROSETTA mission planning.

[1] K. Roessler and K. Thiel (eds.): Proc. 8 Kometenwerkstatt, Rüdesheim 1. - 3. Juni 1993, Forschungszentrum Jülich GmbH, Jülich 1993, 5 - 20.

PROTOTYPE OF A HIGH SENSITIVITY REFLECTRON TIME-OF-FLIGHT MASS SPECTROMETER FOR THE ROSETTA COMET RENDEZVOUS MISSION

S.Scherer , K.Altwegg, H.Balsiger, P.Bochsler, J.Fischer, M.Hohl, E.Kopp, P.Wurz (Physikalisches Institut, Universität Bern, Sidlerstr.5, CH-3012 Bern, Switzerland)
H.Rème (CESR, BP 4346, F-31029 Toulouse, Cedex, France)
B.Wilken (Max-Planck Institut für Aeronomie, Postfach 20,
D-37191 Katlenburg-Lindau, Germany)
H.Wollnik (II.Physikalisches Institut, Universität Giessen, Heinrich-Buff-Ring 14,
D-35392 Giessen, Germany)
D.Young (Southwest Research Institute, POD 28510, San Antonio, TX 78228, USA)

The Rosetta Orbiter Spectrometer for Ion and Neutral Analysis ROSINA is thought to determine the elemental, isotopic and molecular composition of the atmosphere and ionosphere of comets. One of the in situ investigations required to fulfill this objective is a gas and ion mass spectrometer instrument package made up of three sensors. The RTOF (Reflectron Time-Of-Flight) provides a mass range from 1 to well above 500 amu combined with a high sensitivity and high mass resolution.
We will present the design of the RTOF instrument consisting of a pulsed electron-impact storage ion source, a gridless ion reflector and a microchannel-plate detector as well as a status report of the experimental results and the performance of the laboratory prototype.

INFORMATION AND SEARCH FIELD SCIENCE THEORY FOR BETTER PLANNING OF PLANETARY SIMULATION EXPERIMENTS

K. Roessler (Institut für Nuklearchemie, Forschungszentrum Jülich GmbH, D-52425 Jülich, Germany)

In the past decades a number of laboratory simulation studies have been performed in order to investigate potential physical and chemical reactions in solid and gaseous phases of solar system bodies. Due to the lack of a proper science theory for planetary simulations many of these approaches were of a serendipity type. The author is in particular familiar with the comet simulation experiments KOSI in the Small and Big Space Chambers of DLR-Köln and the Cosmic Ray Simulation (CRS) experiments with cyclotron ions and cryostats in Forschungszentrum Jülich. A new science theory for simulation studies is presented which allows a better planning of the experiments. It started from the mono-, bi- and tridimensional representation of groups of expressions in language theory. Information on a planetary body is ordered in terms of chains, fields and spaces using e.g. size, composition, temperature, radiation response etc. as parameters for a multidimensional representation. The simulation is planned within a search field or space. In planetary science with its eventually poor information on a specific object an overlap of information fields from other (similar) bodies has often to be considered. As a general rule it can be concluded that the size of a search field (i.e. the variation of parameters) must be inverse to that of the information field. This means, e.g. for cometary nuclei which are not well known, to perform experiments under rather different conditions instead of a multitude of single parameter studies. The search field theory presents an effective and interdisciplinary approach to the planning of planetary experiments.

LABORATORY STUDIES OF PAHS. CONTRIBUTION TO GROUND-BASED OBSERVATIONS AND TO SPACE MISSIONS

F. Salama (NASA-Ames Research Center, Moffett Field, CA 94035, USA)

Polycyclic aromatic hydrocarbons (PAHs) are considered to be an important and ubiquitous component of the organic material in space. PAHs are found in a large variety of extraterrestrial materials. For example, PAHs are found in interplanetary dust particles (IDPs) and in meteoritic materials (as evidenced by the recent detection of PAHs in a Martian meteoritic sample). PAHs are also considered to be very good candidates to account for the IR emission bands (UIRs) and the diffuse interstellar absorption bands (DIBs) detected in various regions of the interstellar medium (ISM). A major laboratory effort has thus been undertaken to measure the spectral characteristics of these complex molecules under conditions relevant for astrophysical applications. The laboratory program will be discussed in its multiple aspects (objectives, approach and techniques adapted to the nature of the problem, results and implications). In particular, a review of the data generated on the UV, visible and NIR spectroscopy of neutral and and ionized PAHs will be presented together with a discussion of the general/characteristic molecular properties which can be derived from these studies and which present a potential interest for astronomical search. Finally, the contribution of the laboratory data to current and future ground-based astronomical observations and space missions (HST, Rosetta and ISO among others) will be discussed.

DEVELOPMENT OF A MICRO-ROVER FOR PLANETARY EXPLORATION - INVESTIGATION OF A LASER SYSTEM FOR NAVIGATIONAL PURPOSES.

Luca Soli (Politecnico di Milano, Dipartimento di Ingegneria Aerospaziale, Via Golgi 40, I-20133 Milano, Italy)
Lutz Richter (Institute of Space Simulation/MUSC, DLR, Linder Hohe, D-51147 Cologne, Germany)

The exploration of Mars and of the other planetary bodies by micro-robotic devices looks to be very promising. The technologies needed for successfully navigation in different planetary environments are studied.
This paper will present the first results of the investigation concerning a laser based system for the autonomous navigation of micro-rovers.
A laser point source is spreaded by a cylindrical lens in a line, the backscattered light from the rocks is detected by an array of photodiode. In addition the position of obstacle like rocks, will be determinated by triangulation. To reduce the effects of the solar background illumination modulated laser pulse and optics filtering techniques are used. Using these techniques the laser power needed to the operation is very small. Under realistic planetary conditions, the mineral composition, the rock surface properties and the atmospheric mixture have influence on the propagation and on the scattering phenomena of the laser radiation. For a safe navigation these possible reasons of misrouting have to be investigated separately. The sensitive parameters for the system are investigated in the laboratory by experiments and the measurements are compared with the theoretical models.

EXPERIMENTAL STUDIES FOR NUCLEAR ASTROPHYSICS

C. Spitaleri (INFN-Laboratorio Nazionale del Sud, Catania, Italy)

The study of nuclear reactions at very low bombarding energies, corresponding to the stellar temperatures, is a significant support for an understanding of the astrophysical nuclear processes as well as for the description of stellar evolution and the abundance of various nuclides observed in the universe. The calculated production rate of the elements depends strongly on the available experimental data. The possible presence of unpredicted nuclear cross section resonances is particularly important in to understanding the nuclide production through stellar-burning chains. It is well known that the main problem in performing measurements of charged-particle cross section at energies relevant for nuclear astrophysics is mainly connected to the presence of the Coulomb barrier. For this reason, very often the extraction of the astrophysical S-factor at the relevant energies is performed by extrapolation of the experimental information taken at higher energies. This procedure implies the assumption of a theoretical model that contains, usually, some uncertainties. In order to overcome this problem much attention has been devoted to indirect methods. As an example, processes of radiative capture present in the stellar chains are studied by the time-reversed breakup of fast projectiles in the Coulomb field of heavy ions targets. Another method, the Trojan Horse method, uses a high energy projectile that breaks inside the nuclear region in two fragments; one of them will then undergo a nuclear reaction without suffering any coulomb screening, while the second fragment remains uninvolved in the process. Recent results will be presented.

EFFECTS OF DUST GRAINS NON-SPHERICITY ON POLARIZATION AND COLOURS OF COMETS

N.V. Voshchinnikov (Astronomical Institute of St. Petersburg University, Bibliotechnaya pl. 2, St. Petersburg. 198904 Russia)

The comets give the unique possibility to study *simultaneously* the emission, scattering and extinction properties of interplanetary dust grains. This is because photometric and polarimetric observations of the comets themselves in the visual and infrared may be supplemented with observations of stars seen through the comets. To analyze the colours and polarization of comets I utilize a model of aligned homogeneous and core-mantle spheroidal grains. The calculations of the optical properties of such particles have been performed using the solution to the light scattering problem by the separation of variables method. In contrast to previous works, the optical properties of cometary dust are connected with the processes of the production and sublimation of grains, i.e. with the heliocentric distance and preperihelion/postperihelion position of a comet. This means, for example, that the observed dependence of polarization on the phase angle is not determined by the particles of a given sort but by those of different sorts depending on the comet's position relative to the Sun. It is considered how variations of the grain's shape, size, mantle thickness, alignment and porosity affect the cometary colours (Ucont – Bcont, Bcont – Rcont) and polarization at different wavelengths (inversion angle, maxima at positive and negative branches, etc.) as well as the wavelength dependence of extinction and polarization of background starlight by the cometary dust. Observations of the comet Levy (1990 XX) are interpreted using the model suggested.

ON THE EXCITATION AND PROPAGATION OF AXISYMMETRIC SHOCK WAVES IN PROTOPLANETARY ACCRETION DISKS

E. Willerding (Institute for Astrophysics and Space Research, University of Bonn, Auf dem Hügel 71, 53121 Bonn, Germany)

We have investigated in the so–called local shearing sheet model the hydrodynamics of axisymmetric density disturbances under the simultaneous action of viscosity and gas pressure. Self–gravity can be neglected in a first approximation. It is possible to solve a special initial–boundary value problem simulating the interaction of a slowly rotating protostar with an accretion disk. The model solutions so obtained describe both the excitation and propagation of 'overstable' acoustic density waves in the medium. The phase velocity of the individual waves is supersonic. The suggested processes in the linear theory should initiate in the non–linear regime the formation of narrow ring–shaped shock waves moving through the protoplanetary disk. We speculate that these shock waves, excited by inner boundary conditions, are responsible both for the fast growth of dust to planetesimals as well as for the rapid accretion of the rocky cores of giant gaseous planets in our solar system. It is also very likely that these shock waves could serve as a trigger-mechanism for local transient high-energy processes in the dust-gas disk and therefore could be responsible for the formation of chondrules and refractory inclusions in some meteorites.

LARGE PLASMA DEVICE FOR MODELING SPACE PHENOMENA

A.V. Strikovsky and V.I.Gundorin, A.V. Shaykin, M.V. Starodoubtsev, A.V. Kostrov (Institute of Applied Physics RAS, Ulyanov str. 46, Nizhny Novgorod, 603600, Russia)

IAP have large experimental device "KPOT" allowing produce magnetoplasma The main direction in real time is investigation of interaction and propagation of intense whistler range waves with magnetoplasma ($\Omega_H \leq \omega_0 \ll \omega_{He} < \omega_{pe}$), where Ω_H is lower-hybrid frequency, ω_0 is wave frequency, ω_{He} and ω_{pe} are plasma and cyclotron frequency respectively. Device for experiments of wave-plasma interactions in magnetoplasma consist of the following:
A solenoidal current-carrying coil (1.5 m in diameter, 3.5 m length) to provide the pulsed magnetic mirror ($B < 1000\ G$, $t \sim 20\ ms$) is situated inside a vacuum chamber (3 m in diameter, 10 m length). The trapped plasma is produced by a pulsed inductive rf-discharge. To get uniform axial plasma profile, four current loops (1.2 m in diameter) placed in the magnetic mirror and fed with two rf-power supply 1 MW each are used ($t \sim 1\ ms$, $f = 5\ MHz$). Most measurements are being obtained in the afterglow plasma (e-folding decay time $\sim 1.5\ ms$, $N_{max} \simeq 2 \cdot 10^{12} cm^{-3}$, $T_e \simeq T_i \simeq 0.5\ eV$). The radial density profile is close to parabolic one. The large size of laboratory magnetized plasma gives the possibility to study propagation of unbounded waves in detail. For example whistler wave-particle interaction indispensable for an understanding of the triggering mechanisms, parametric instability whistler waves near the lower-hybrid resonance level and so on.

WHICH SPECTRAL RANGE IS THE MOST PROMISING ONE FOR CARBONATE DETECTION ON MARS?

C. Wagner (Institut für Planetenerkundung, DLR Forschungszentrum Berlin-Adlershof, Rudower Chaussee 5, 12484 Berlin)

In spite of extensive search carbonates have not been found until now on the Martian surface by spectroscopic methods. This is surprising because a carbonate content up to 5 or even 10% is suggested by (i) theoretical conceptions about the weathering processes of Martian crustal rocks, and (ii) further arguments, e.g. the Viking chemical analyses of Martian soil. But also the recent earth-based Mars spectra, covering the wavelength range 2-4.2 µm (Blaney and McCord 1989, Roush et al. 1992), provided no spectral evidence for carbonates in the Martian soil. This could be due to the fact that the diagnostic feature at ~4 µm, which is a trough in the reflectance spectrum, is partially filled by Mars' thermal emission (Wagner and Schade 1996).
In the present laboratory study it is investigated, whether a better chance for carbonate detection may be expected for the pure emission spectrum in the thermal infrared, i.e., by using the carbonates' fundamental vibration bands (at e.g. about 7, 11.5 and 13.5 µm). For this purpose spectra were measured for mixtures consisting of palagonite (as a Mars soil analogue) with various percentages of carbonates. The band depths of the diagnostic features were estimated and compared with those obtained previously for the 4-µm feature.

LIGHT SCATTERING BY DUST PARTICLES IN MICROGRAVITY: RECENT RESULTS

J.C. Worms (ESSC c/o ENSPS, Parc d'Innovation, Bd. Sébastien Brandt, F-67400 Illkirch France)
J.B. Renard (LPCE CNRS, 3A av. Recherche Scientifique, F-45071 Orléans Cedex 2), A.C. Levasseur-Regourd and E. Hadamcik (CNRS Aéronomie, BP 3, F-91371 Verrières Cedex)

The PROGRA^2 instrument has been successfully designed to measure the polarimetric phase functions of dust samples under microgravity conditions. Parabolic flight campaigns on board the CNES "Zero G" and the NASA KC-135 aircrafts in 1994 and 1995, have led to the production of polarimetric phase curves which we have already reported in the litterature. Maximum polarisation was found to be smaller and to occur at lower angles (≈ 90°) in microgravity than under 1 "g". The instrument is now operational and can achieve the measurement of up to six phase curves per campaign, at the foreseen rate of two campaigns per year. Upgrading of the instrument was carried out in the past months to solve the problem of particle sticking to the walls of the containers. An ultrasonic device was developed to overcome the Van der Waals forces preventing smaller particles to freely float in the containers during microgravity. The PROGRA^2 instrument took part in the last CNES campaign on the NASA aircraft in November 1996, during which six Silicium carbide samples were tested, yielding measurements throughout the whole phase angle range (15° - 170°). These new results will be presented, along with the upgraded configuration of the instrument.

$V_P \times B$ ELECTRON ACCELERATION USING TE MODE

N. Yugami and **Y. Nishida** (Utsunomiya University, Department of Elecrical and Electronic Engineeri ng, 2753 Ishii-machi, Utsunomiya, Tochigi 321 JAPAN)

Electron linear accelerator, using slow transverse electromagnetic wave (TE wave ; 10 kW) supplemented with crossed static magnetic field, has been demonstrated. An energy gain of 10.5 keV for electrons is observed from an incident energy of 62 keV in a 0.5 m accelerator, when an external magne tic field of 2.0 G is applied. The results show the feasibility of higher gradient and compact accelerator usin g an intense laser or short wave length microwave without slow-wave structure.

OBSERVATION OF LARGE-AMPLITUDE ION ACOUSTIC WAVE IN MICROWAVE-PLASMA INTE RACTION EXPERIMENTS

N. Yugami and **Y. Nishida** (Utsunomiya University, Department of Elecrical and Electronic Engineeri ng, 2753 Ishii-machi, Utsunomiya, Tochigi 321 JAPAN)

Large amplitude ion acoustic wave, which is not satisfied with a linear dispersi on relationship of ion acoustic wave, is observed in microwave-plasma interaction experiments. This ion acoustic wave is excited around critical density layer and begins to pr opagate to underdense region with a phase velocity one order faster than sound velocity C_s, which is predicted by the linear theory, the phase velocity and the wave length of the wave decreases as it propagates. Finally, it converges to C_s and strongly dumps. Diagnostic by the Faraday cup indicates that this ion acoustic wave is accompani ed with a hot ion beam.

PS10 Meteorites and cosmochemistry

Convener: Jagoutz, E.
Co-Convener: Kurat, G.

MG ISOTOPE FRACTIONATION IN THE E2 CAI TYPE A FROM THE EFREMOVKA CV3 CHONDRITE.

S.V. Afanassiev (Vernadsky Institute, Russian Academy of Sciences, Kosygin St. 19, Moscow, Russia 117975)

We have measured the $^{25}Mg/^{24}Mg$ ratio in melilite from the rim to the interior of the E2 using ion microprobe techniques. At the distance of ≈ 55 μm from the rim we indicate a sharp increase of the ratio. Further the ratio decreases but it is higher in the E2 core than that at its margin. The measured profile differs from that obtained by [1, 2]. However at a distance of more than 130 μm from the rim our data are compatible with measurements [1, 2].

Results of the study and the data [1, 2] indicate significant radial and lateral heterogeneity of the Mg isotopic composition in the E2 margin area. The heterogeneity is not compatible with mass fractionation of Mg isotopes during volatilization of the E2 melt, which should lead to a similar isotopic distribution in different parts of the inclusion. A gas-solid isotopic exchange could explain better the heterogeneity because this process is dependent on the structure of the inclusion. In this case the isotopic profiles should record a change of Mg isotopic composition in the gas environment. It could be related to a transportation of the inclusion in the solar nebula.

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HOW CONVINCING ARE THE EVIDENCE OF THE MARTIAN LIFE OBTAINED FROM ALH 84001 METEORITE

E.M. Galimov (V.I.Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences, Kosygin Street 19, Moscow 117075, Russia)

It is shown that the isotope and mineralogical data for the ALH 84001 meteorite admit interpretation different of that presented by McKay et al. (*Science*, 16 August, 1996). These authors argue that the mineral assemblage observed in the carbonate globules in the ALH 84001 meteorite formed at 0° to 80°C and had biogenic origin. However calculation of oxygen isotope fractionation and mineral equilibrium shows that it is most likely that the carbonate globules were formed inorganically under high temperature conditions (~700°C) and subjected to secondary aqueous alterations under temperatures of about (~150°C). The aqueous solution which altered the primary carbonates did not bring any (or brought little) additional CO_2 leaving the ^{13}C - composition of the reprecipitated carbonate material almost unchanged.

SIMULATION OF MELTING-CRYSTALLIZATION RELATIONSHIPS IN CHONDRITIC AND ACHONDRITIC IGNEOUS SYSTEMS

A.A.Ariskin (Vernadsky Institute, Kosygin Str. 19, Moscow 117975, Russia)
M.I.Petaev (Harvard-Smithsonian Center for Astrophysics, Cambridge, MS 02138, USA)

We present the METEOMOD computer program designed for the calculations of melting-crystallization relationships in igneous systems compositionally similar to ordinary chondrites and basaltic achondrites. The basic block of METEOMOD is a set of empirically calibrated equations, which describe equilibria between silicate melt and minerals such as olivine, orthopyroxene, pigeonite, augite, plagioclase and metallic iron in terms of pressure, temperature, oxygen fugacity, and liquid compositions. The mineral-melt geothermometers are calibrated on the database including only FeO enriched compositions of melts produced in melting experiments on meteoritic, lunar basalt and synthetic systems. The program calculates crystallization temperatures and contents of major end-members in the minerals with the accuracy of ±10-15°C and ±1-2 mol%, respectively. The input parameters include: (1) contents of 10 major elements plus 20 trace elements; (2) increment in crystallization degree; (3) oxygen buffer; and (4) terminal crystallization degree. The output consists of a series of tables which list the equilibrium state information as a function of the percent crystallized. The results of application of the METEOMOD are demonstrated for partial melting of the St.Severin LL chondrite.

CALCULATION OF PARENTAL MAGMA COMPOSITION FOR ALH84001 ORTHOPYROXENITE

A.A.Ariskin (Vernadsky Institute, Kosygin Str. 19, Moscow 117975, Russia)

Using the METEOMOD model we calculated the course of equilibrium crystallization of a melt corresponding to the bulk composition of ALH84001 [1,2]. The calculations were carried out at 1 atm pressure, with the crystal increment of 1%, *f*O2 values being 1 log unit lower *QFM* buffer, and in the range of crystallinities 0-94 wt.% (100-6% of melting). The modeled crystallization sequence of silicate minerals is: *Ol*(1490C)→ *Ol+Opx*(1465C) → *Ol+Opx+Pl* (1143C) with *Ol* being in the reaction relations with *Opx*. Compositions of partial melts at 6 and 16% of melting are listed in the table:

F,%	T, C	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5
6	1143	52.59	2.40	17.44	13.80	0.27	5.26	5.23	2.54	0.32	0.16
16	1256	52.25	1.02	7.37	21.33	0.49	9.39	6.94	1.02	0.13	0.06

The calculated mafic mineral compositions at 6% of melting (Fo67, En70Fs26) are close to those observed in ALH84001 [1,3], however our calculations indicate that the observed spinel composition [1] is too depleted in Al to be in equilibrium with such a high-Al basalt parent. Despite more magnesian mineral assemblage (Fo69, En73Fs25), the *F*=16% liquid composition is more suitable as a parental magma for the othopyroxenite.

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THE FERMO METEORITE: A NEW FALL

G.Bonino, G.Cini Castagnoli, P. Della Monica and C.Taricco (Dipartimento di Fisica Generale dell'Università, Via P.Giuria 1, 10125 Torino, Italy and Istituto di Cosmogeofisica del CNR, Corso Fiume 4, 10133 Torino, Italy)
N.Bhandari (Physical Research Laboratory, Ahmedabad, India)

A meteorite fell at Fermo, central Italy, on 25 September 1996. Petrographic studies performed by Molin (personal communication) indicate that the stone is an H3-5 chondrite. Chemical analyses of the meteorite are reported here.
Twelve cosmogenic radioisotopes with half life ranging between 16 days to 7.3 10^5 years have been measured by us with high precision, by non-destructive technique, utilizing the low background γ-spectrometer of the underground Laboratory (70 m.w.e.) of Monte dei Cappuccini in Torino. We have been able in particular to measure the very low activity of ^{44}Ti ($T_{1/2}$=66.6 years) which is useful for studying the effects of the century scale solar modulation (1). The measurements of the isotopic composition of He, Ne, Xe and of nuclear track densities are in progress at PRL.

BORON AND LITHIUM ISOTOPIC HETEROGENEITY OF METEORITIC CHONDRULES

M. Chaussidon (CRPG-CNRS, BP 20, 54501 Vandoeuvre-lès-Nancy, France)
F. Robert (MNHN-CNRS, 61 rue Buffon, 75015 Paris, France)

Li, Be and B are the only three chemical elements whose nucleosynthesis does not occur in stars or during the Big-Bang. We have recently reported large B isotopic variations in single meteoritic chondrules, up to ≈70‰ around $^{11}B/^{10}B$ = 4.05. These isotopic variations have been interpreted as the result of the mixing in the early solar nebula of two components having distinct nucleosynthetic origins : a ^{11}B-rich component produced by low-energy (10-30 MeV) spallation reactions that occurred in the pre-solar interstellar cloud ($4.3<^{11}B/^{10}B<5.1$) and a ^{11}B-depleted component present in the cloud before its irradiation ($^{11}B/^{10}B \geq 2.5$). Theoritical considerations suggest that an imprint of these nucleosynthetic processes must also be present in the Li isotopic composition of chondrules. We present here new data showing the variation of the $^{11}B/^{10}B$ and $^{7}Li/^{6}Li$ ratios in chondrules. Correlations between these ratios and either Li or B or major element contents are used to decipher the nature of the chondrule precursors which have preserved pre-solar isotopic heterogeneities.

INTERSTELLAR WATER IN METEORITIC CHONDRULES

E. Deloule (CRPG-CNRS, 15 rue Notre-Dame des Pauves BP20; 54 501 Vandouuvre-Nancy Cedex FRANCE)
J-C Doukhan (Lab. Etat Solide; Univ. Sciences &Techniques. 59 655 Villeneuve d'Ascq. Lille CEDEX FRANCE)
F. Robert (CNRS - Muséum Nat. Hist. Nat. Lab. de Minéralogie, 61 rue Buffon, 75005 Paris FRANCE)

A large content of hydroxides in the pyroxenes of meteoritic chondrules has been identified as submicroscopic amphibole lamellae. Isotopic studies of these water rich area (up to 4550 ppm H_2O) have shown that they have retained their pristine interstellar D/H ratios (D/H up to 479±8 $x10^{-6}$). The mesostasis of these chondrules have been subjected to an intense alteration with a different source of water having D/H ratio close to the protosolar value (D/H down to 63±12 $x10^{-6}$). The mixing of the two isotopic components yields a mean D/H ratio close to that in bulk carbonaceous chondrites and on Earth. Based on these isotopic records, mass balance calculations show that 14±3 % of the terrestrial ocean is of interstellar origin and 86±3% resulted from an oxidation of the protosolar gas. Similarly less than 10% of water on the present day Earth was inherited from the early cometary bombardment.

LOCALIZATION AND NATURE OF VOLATILES IN THE LUNAR REGOLITH

Yu.P. Dikov (IGEM, RAS Moscow), F.Wlotzka (MPI Chemie, Mainz, FRG)
A. V. Ivanov and O.I. Yakovlev (Vernadsky Institute, RAS Moscow)

Our X-ray photoelectron spectroscopic data for the fine fractions of the Luna-16 regolith show a high enrichment of volatile elements in the surface layers of *all* grains: carbon up to 60 at%, Zn, Cd and Pb in the at% range [1]. TEM diffraction patterns show the carbon to be in the form of nano-diamonds (lonsdaleite). From our experimental investigations of high-temperature evaporation of meteorites [2] and a comparison of the distribution of volatile elements between lunar crystalline rocks and fines, we conclude that this enrichment in volatiles is the result of exogenic pollution of the lunar surface due to cosmic bombardment. The high amount of carbon in the surface layers points to a contribution from comets. These surface enrichments are similar to those found for the volatiles in the "volcanic" orange glasses, and it suggests a similar origin for these volatiles, and perhaps also for the glasses.

TRACE ELEMENT VARIABILITY ASSOCIATED WITH THE LATE EOCENE CHESAPEAKE BAY IMPACT CRATER

D. W. Edsall (U. S. Naval Academy, Annapolis, Maryland)
D. S. Powars (U. S. Geological Survey, Reston, Virginia)

Concentrations of 14 elements in a suite of samples from two late-Eocene sediment cores drilled on the eastern shore of Virginia have been determined using a Particle-Induced X-ray Emission (PIXE) spectrometer. The samples were bombarded in air with 2.75 MeV protons. Characteristic x-rays were detected using a lithium-drifted silicon detector and a 0.060-inch-thick acrylic absorber to reduce the intensity of the low-energy x-rays. Sensitivity calibrations were performed with various USGS standards.
The Kiptopeake site lies within the 20-mile diameter basement crater. The Exmore site lies near the outer edge of the 55-mile diameter outer trough. Analysis of samples across the contact between the bathyal-depth Chickahominy clays and the polymictic impact breccias show variations in elemental concentrations, especially Cu, Zn and Ti. Reasons for these observed variations are explored.

Evolution of SNC Meteorites

E. Jagoutz (Max-Planck-Institut für Chemie, Postfach 3060, D-55020 Mainz, Germany)

New isotopic data measured especially on EETA 79001 and Chassigny permit a considerable refinement in the evolution model of SNC meteorites. From the examination of the Rb-Sr, Sm-Nd and the U-Pb isotope systematic we must conclude that only two differentiation processes dominated the evolution of the SNC meteorites. The first and primary differentiation occurred 4.5 Ga ago, the second between 150 Ma and 1.4 Ga. The first differentiation formed chemically distinctive reservoirs from primary accreted material. The second differentiation process mainly created the final chemical and mineralogical composition of the SNC meteorites as they are today. While the first differentiation followed a magmatic fractionation process, the second fractionated mainly the Sm/Nd ratio without significant changes of the Rb/Sr system. A subsolidus reaction might be responsible for this chemical changes.

INCOMPATIBILITY OF BULK MOON AND EARTH'S MANTLE COMPOSITIONS

P. Jakeš (Institute of Geochemistry, Mineralogy and Mineral Resources, Faculty of Science, Albertov 6, Praha 2, Czech Republic. E-mail: jakes@prfdec.natur.cuni.cz

Moon has formed due to the collison of Mars size body with the Earth. Major differentiation of the Moon has taken place through the melt - crystal equilibrium. The idea of molten Moon is derived from the observation of lunar highlands. The geochemical features of the Moon, i.e.,lack of the volatiles, excess of refractories, depletion of siderophiles are distinctly different from the upper mantle of the Earth that mode of origin from a single source are little compatible. High content of refractory elements is sought in the composition of impactor or in the secondary volatilization. An another possibility is the formation of the Moon in the early history of the Earth that had (at that stage) different composition than contemporaneous upper mantle. Volatilization, refractory composition, and reduced nature are mutually related through high temperature event.The siderophile and moderately siderophile elements are reduced, the rest is subjected to vaporization. Refractory elements are retained in the mantle. At this stage the Moon is formed and hence its composition represents lower mantle of the Earth. Although the estimates of bulk Moon composition differ bulk Moon must provide a melt that crystallizes large amount plagioclase. Common features of Moon composition are high contents of Al,Ca,U,Th, etc. If the early Earth (70% formed) has refractory composition similar to Moon, the lower mantle mineralogy is different than assumed Mg-perovskite.

COMETARY/METEORITIC LINK: IMPACT MODIFICATION OF ORGANIC MATERIAL.

A. V. Korochantsev, D. D. Badjukov, and L. V. Moroz (Vernadsky Institute, Russian Academy of Sciences, 117975 Moscow, Kosygin St. 19, Russia)

Effects of shock-induced modifications of organics were studied on a natural solid bitumen - *asphaltite*, shock -loaded up to 17.3-80 GPa. XRD analysis of samples shock-loaded up to 26.7 GPa shows the percentage of aromatic layers (fa), the average interlayer distance (d_{002}), and the average height of aromatic clusters (Lc) do not change significantly as compared to initial asphaltite (fa~0.2, d_{002}~3.7Å, Lc~9Å). FTIR spectra of the samples show a bulk reflectance decrease and some loss of CH_2 and CH_3 groups, while intensities of aromatic absorption bands don't change drastically. The samples preserve the initial *asphaltite* structure. For a sample shock-loaded at 60 GPa, fa value increased to 0.65, Lc - to 19Å, reflection d_{002} shifted to 3.48Å; a drop of the bulk reflectance, a loss of CH_2, CH_3 and O-bearing groups, a disappearance of aliphatic chains with C>4 and a relative increase of intensities of aromatic C-H and C=C bands are observed. These features are typical of more ordered bitumens - *high kerites*. For a sample shock-loaded at 80 GPa the parameters change drastically: fa=1, d_{002}~3.4Å and Lc~76Å. The sample is darker in an IR region and its spectrum becomes featureless. These parameters are similar to those of *shungites*. Since asphaltite is a possible analog of organics of comets and P, D asteroids, one can raise a question of that kerite-and anthraxolite-like C chondrite organics might be produced from asphaltite-like cometary organics by impacts.

THERMAL RELEASE OF VOLATILES FROM MARTIAN METEORITE ZAGAMI

A.P. Koscheev, I.A. Panin (Karpov Institute of Physical Chemistry, ul.Vorontzovo Pole 10, Moscow, 103064, Russia)
L.M. Mukhin (Space Research Institute, RAS, ul.Profsoyuznaya 84/32, Moscow, 117810, Russia)
G. Dreibus and H. Wänke (Max-Planck-Institut für Chemie, Saarstrasse 23, D-55122, Mainz, Germany)

The release of gases from powdered samples of Martian meteorite Zagami during programmed heating up to the melting point both in vacuum and in oxidative environment was studied by mass spectrometry.
The measured volatiles are water vapour, carbon oxides, hydrocarbons and sulphur containing species which could be analysed quantitatively. The temperature profiles of evolved gases were measured in two temperature ranges from 20°- 600° C and 600°-1200° C. For comparison the gas release studies were extended to Murchison (C2-chondrite) and MORB samples. The results obtained were interpreted on the base of mineral composition of the samples and possible chemical reactions between solid phases. It was shown that even small traces of oxygen in the gas phase can drastically increase the amount of sulphur dioxide evolved at high temperatures. The possible implications of the results to the Martian condition are discussed.

INERT GAS IMPLANTATION INTO ARTIFICIAL ANALOGUE OF METEORITIC NANODIAMONDS

A.P. Koscheev, M.D. Gromov (Karpov Institute of Physical Chemistry, ul. Vorontzovo Pole 10, Moscow, 103064, Russia)
U. Ott (Max-Planck-Institut für Chemie, Becherweg 27, D-55128 Mainz, Germany)

Noble gases trapped in the diamond micrograins found in primitive meteorites show unusual isotopic compositions. As these microdiamonds are considered to constitute surviving interstellar material, their origin as well as the origin of inert gases in them is an important problem in cosmochemistry. We undertook an attempt to simulate the process of ion implantation into the interstellar diamond grains by using synthetic detonation nanodiamonds as an analogue in the laboratory. The temperature dependence of xenon release after implantation of xenon ions was measured by mass spectrometry in the temperature range up to 1000C in vacuum. The effects of primary ion energy and dose as well as the preparation procedure on the release patterns of xenon were investigated. The results are compared with the data for meteoritic diamonds.

ALH84001: A VARIETY OF FLUID ACTIVITIES

G. Kurat[1], M.A. Nazarov[2], P. Hoppe[3], F. Brandstätter[1], and C. Koeberl[4] [1]Naturhistorisches Museum, A-1014 Vienna, Austria; [2]Vernadsky Institute, 117975 Moscow, Russia, [3]Physikalisches Institut, Universität Bern, CH-3012 Bern, Switzerland; [4]Institut für Geochemie, Universität Wien, A-1090 Vienna, Austria

Meteorite ALH84001 is a brecciated orthopyroxenite, which is widely believed to originate from Mars. There was a recent claim regarding the existence of possible relics of biological activity in ALH84001. However, a variety of mineralogical and petrological features are more consistent with fluid activities, most of them probably related to fairly high temperatures. The succession of events comprises: (1) filling of voids and cracks with chromite; (2) filling of voids and cracks with feldspathic glass (or feldspar, which was later converted into glass); (3) precipitation of silica in veins and triple point pockets; (4) carbonatization of a pre-existing Fe-Mg silicate (olivine ?) and precipitation of carbonates in cracks; (5) growth of magnesite at the expense of Fe-Mg-Ca carbonate (formation of carbonate "globules"). Processes 3 and 4 could have been contemporaneous. The association of magnesite with magnetite, pyrite, and ferriferous chromite indicates conditions of high O, CO_2, and S fugacities, with oxidation increasing toward the final formation of magnesite.

NA-MG-SILICATES AS PLAUSIBLE MINERAL CONSTITUENTS OF METEORITES AND THE DEEP MANTLE OF EARTH AND OTHER TERRESTRIAL PLANETS

Yuriy A. Litvin (Institute of Experimental Mineralogy, Russian Academy of Sciences, Chernogolovka, Moscow district, 142432 Russia)
Tibor Gasparik (CHIPR and Department of Earth and Space Sciences, SUNY, Stony Brook, NY 11794, USA)

The Na-Mg-silicate $Na_2Mg_5Si_{12}O_{30}$ is the main component of roedde rite, found in Indarch and Wichita County meteorites (Fuchs et al. 1966; Olsen et al. 1967). Experiments reported by Gasparik and Litvin (Eur J Min 9. 1997) suggested that Na-Mg-silicates may be stable in the mantle of Earth: $Na_2Mg_2Si_2O_7$ replaced nepheline in nepheline-normative compositions and expected to be common in the mantle above 13 GPa. The stability of Na_2MgSiO_4, $Na_2Mg_2Si_2O_7$ and $Na_2Mg_2Si_6O_{15}$ were investigated using the anvil-with-hole apparatus at Chernogolovka and the split-sphere anvil apparatus at Stony Brook. Na_2MgSiO_4 breaks down to $MgO + Na_2SiO_3$ above 6 GPa and 1600°C; its melting relations were studied to 22 GPa $Na_2Mg_2Si_6O_{15}$ disproportionates to $MgSiO_3 + Na_2SiO_3 + SiO_2$ (quartz or coesite) above 3.0 GPa and 1300oC. $Na_2Mg_2Si_2O_7$ transforms into a new polymorph (bet a phase) above 3.5 GPa and 1350°C; its melting curve was determined to 22 GPa. A similar behavior is expected for $Na_2Mg_2Si_3O_{10}$ and $Na_2Mg_5Si_{12}O_{30}$. Further studies of the Na-Mg-silicates may provide new constraints on the mineralogy, chemistry and evolution of the terrestrial mantles and meteorites.

Geochemistry of the Boltysh Crater's Rocks

K. A. Lorenz (Vernadsky Institute of Geochemistry and Analytical Chemistry, Moscow, Kosygin Str. 19, 117 975, Russia)

The Boltysh impact structure (N 48 45'; W 32 10'), located in a central part of the Ukrainian Shield (Ukraine) is a 24 km diameter complex crater. The rocks of the thick (300 m) impact melt sheet are tagamites. The composition of the rocks have been presented earlier in several publications [1,3]. Here we report additional geochemical data on the impact melt sheet, and the crater ejecta (allogenic breccia). We analysed 22 samples of glassy-matrix tagamites from the drill cores B-11475 (interval 657-762m.) and B-50 (657-732 m), and 2 samples of the allogenic breccia using XRF (major elements), INAA (minor and trace elements), and ICP (Cu,Zn). The tagamites are found to be distinctly depleted in SiO_2 and K_2O as compared to the target rocks [3,4]. Other major elements do not show significant differences in the targer and tagamites. Variation of REE and trace element concentrations is mush lower in tagamites than that in the target granites [2,3].

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THE MN-CR SYSTEM AND THE FIRST 10 MA OF SOLAR SYSTEM EVOLUTION.

G. W. Lugmair, University of California San Diego, USA, and Max-Planck-Institute for Chemistry, Mainz, Germany.
A. Shukolyukov, University of California San Diego, USA.

Over the last few years the study of events in the early solar system with a time resolution of ~1 Ma became reality and has yielded unique and important results. This came about due to the use and application to various meteorite samples and types of a short lived chronometer based on the decay to ^{53}Cr of now extinct ^{53}Mn ($T_{½}$ = 3.7 Ma). We were able to show that the first differentiates (basalts) on a planetesimal in the asteroid belt solidified already about 2 Ma after high temperature refractory pebbles had condensed from the solar nebula. This finding not only requires that the accretion of planetesimals from nebular dust was a very rapid process but also, that heating of these newly formed bodies caused rapid melting and differentiation, leading to core formation within that short period of time. In addition, the isotopic evidence clearly indicates that the bulk chemical characteristics of this planetesimal points towards a chondritic nature of its precursor material. Another striking discovery comes from a comparison of the relative isotopic abundance of ^{53}Cr in Earth, Mars (SNC meteorites), and in meteorites originating from the asteroid belt. The resolvable difference in ^{53}Cr between these materials shows that a gradient of $^{53}Mn/^{55}Mn$ must have existed in the solar nebula where the abundance of ^{53}Mn increased with the distance from the sun. The origin of this gradient is still under investigation.

COSMIC DUST FROM CAP-PRUDHOMME AND SOUTH POLE, ANTARCTICA

M. Maurette[1], S. Taylor[2], C. Engrand[3], J. Lever[2], G. Kurat[3], T. Ntaflos[4]. [1]C.S.N.S.M., F-91405 Campus-Orsay, France; [2]C.R.R.E.L., Hanover, NH 03755-1290, USA; [3]Naturhistorisches Museum, A-1014 Vienna, Austria; [4]Institut für Petrologie, Universität Wien, A 1090 Vienna, Austria.

Unmelted and partially dehydrated micrometeorites as well as cosmic spherules were recovered from both, the blue ice fields near the French station of Dumont D'Urville and the water well of the South Pole station. The cosmic dust collections from these sites differ from each other, a situation which suggests a change in the composition of the micrometeorite flux with time. The cosmic spherules, which are robust against terrestrial weathering, are likely to provide an unbiased sample of the flux and seem to keep memory of such changes over long storage times.

THE FERMO METEORITE: A NEW FALL IN ITALY

G.Molin (Dipartimento Mineralogia e Petrologia, Corso Garibaldi 37, 35100 Padova)
A.M.Fioretti (Centro Studi Geodinamica Alpina del CNR, Corso Garibaldi 37, 35100 Padova)
G.Cevolani (Istituto FISBAT del CNR, via Gobetti 101, 40129 Bologna)

On September 25, 1996 a stony meteorite fell in Central Italy at a site (13° 45' 12"E, 43° 10' 52" N) close to a field, some 3-4 km North-East of the town of Fermo and a few kilometres from the Adriatic coast. The meteorite was recovered two days later as a single stone (size 19x24x16 cm) weighting 10.2 kg within a crater of 30-40 cm and now is housed at the Polar Museum of Villa Vitali in Fermo.
The exposed surfaces of two broken chips of 4.2 and 15.1 g respectively when examined visually and under a low-magnification stereomicroscope, display areas of varying grey also characterized by subtle differences in texture and grain size. One polished thin section was examined under a polarizing microscope in transmitted and reflected light, and the chemical composition of mineral phases and glass were determined by using an electron microprobe. The relatively low FeO/(FeO + MgO) ratios of olivine and low-Ca pyroxene measured in centrimetric to millimetric dark and light clasts cemented by a grey matrix, and petrologic type determination according to Van Schmus and Wood (1967) criteria, allow the Fermo meteorite to be classified as a genomictic, regolith breccia of chondritic group H, with fragments of petrologic types 3 to 5.

s-PROCESS ZIRCONIUM IN PRESOLAR SILICON CARBIDE FROM THE MURCHISON METEORITE*

G. K. Nicolussi[1,2], A. M. Davis[1], M. J. Pellin[2], R. S. Lewis[1] and R. N. Clayton[1] ([1]Enrico Fermi Institute, University of Chicago, Chicago, IL 60637, USA; [2]Materials Science/Chemistry Divisions, Argonne National Laboratory, Argonne, IL 60439, USA)

Mainstream presolar SiC grains from the Murchison meteorite are known to have a number of isotopic characteristics of nucleosynthesis in asymptotic giant branch (AGB) stars. Isotope ratios of a number of light elements (C, N, Mg, Si, Ca, and Ti) have been measured in individual presolar SiC grains, but those of heavy elements (Kr, Xe, Ba, Nd, and Sm) have been measured only in aggregates of many grains. We report here Zr isotopic compositions of 12 individual presolar Murchison SiC grains (3–6 μm), measured by laser resonance ionization and time-of-flight mass spectrometry of laser desorbed Zr atoms. All grains analyzed show depletions in ^{96}Zr, an *r*-process isotope, relative to the other isotopes of Zr, all of which are produced by the *s*-process. Relative to ^{92}Zr and terrestrial Zr, the grains have $\delta^{96}Zr$ values of –1119±225 to –441±143 ‰ (±2σ). Nucleosynthesis calculations by Gallino et al. (pers. comm.) on 1.5 and 3 solar mass AGB stars show that Zr with progressively larger ^{96}Zr deficits is produced in a series of third dredge-up and envelope mixing episodes. In these models, the dominant neutron source is $^{13}C(\alpha,n)^{16}O$, which produces only ^{90}Zr, ^{91}Zr, ^{92}Zr, and ^{94}Zr, but $^{22}Ne(\alpha,n)^{25}Mg$ becomes important in later episodes and can produce ^{96}Zr by neutron capture on 64-day ^{95}Zr. The large deficits seen in ^{96}Zr suggest that ^{22}Ne was not a significant neutron source in the AGB stars producing the grains we analyzed.

COMPUTER MODELING OF ORDINARY CHONDRITE MELTING

M I. Petaev (Harvard-Smithsonian Center for Astrophysics, Cambridge MA 02138, USA)
A A Ariskin (Vernadsky Institute, Ul. Kosygina 19, Moscow 117975, Russia)

Using the METEOMOD computer program [1,2] we calculated phase relations in 9 partially-to-completely (~10 - 100% melt) molten chondritic igneous systems at 1 atm and log f_{O2} of 1-2 log units below the IW buffer. Chemical compositions of the systems modeled correspond to those of bulk (minus Cr_2O_3, FeS and Ni) H, L, and LL chondrites [3] and also metal-free and volatile-depleted (minus ~90% Na_2O, K_2O and $P2O_5$) chondrites. The calculations were performed at 0.5% increment in crystallization degree. Variations in f_{O2} have only minor effects on the melt compositions at similar melting degrees. The only exclusion is the melts formed in the bulk H chondrite system due to its high metal content. At log f_{O2} of 1.9 -1.8 log units below the IW buffer, the maximum metal contents in residues equilibrated with partial melts in H, L and LL chondritic systems approximate those of H, L and LL chondrites, respectively. In general, ~10 % partial melting produces melts too siliceous (~56 % SiO_2) and aluminous (17-19 % Al_2O_3) to be basaltic. Removal of metal does not affect melt compositions significantly, but depletion in volatiles results in ~100°C higher temperatures at ~10 % melting and production of broadly basaltic melts.

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Chemical analysis of Martian surface with APXS on Mars Pathfinder mission.

R. Rieder, J. Brückner and H. Wänke, MPI für Chemie, Mainz, Germany
T. Economou and A. Turkevich, LASR, University of Chicago

The US Mars Pathfinder, now on its way to Mars, is carrying among other payload an Alpha Proton X-ray Spectrometer (APXS) -- an analytical instrument that will provide for the first time a complete chemical composition not only of soil, but hopefully also of several Martian rocks. The APXS will be carried around on the surface of Mars by the Pathfinder microrover Sojourner that provides it with mobility to analyze interesting samples selected from the panoramic images from the lander camera or from the images from the color high resolution aft microrover camera.

In the meantime, using the spare flight instrument in the laboratory, many samples of known and unknown composition are being analyzed in order to derive the element standard library that is necessary to perform the Martian sample analyses. It is expected that the APXS will determine all the major elements present in amounts above several tenths of a percent and it will detect many minor and trace elements present in several hundreds ppm level. It will for the first time return data on the amount of carbon in the soil, and, hence, shed light on the question of the presence of carbonates.

The technique and the instrument will be described and examples of analyses and energy spectra from many samples will be presented and discussed in details.

The Mars Pathfinder was launched from Kennedy Space Center on December 4, 1996. It is scheduled to land on the surface of Mars on July 4, 1997.

IN SITU MEASUREMENT OF COSMIC DUST AND SPACE DEBRIS IN THE GEOSTATIONARY ORBIT

H. Svedhem, G. Drolshagen (ESA/ESTEC, Pb 299, 2200 AG Noordwijk, The Netherlands)
Eberhard Grün (Max Planck Institut für Kernphysik, Heidelberg, Germany)
Oleg Grafodatsky (NPO-PM, Krasnoyarsk, Russia)
Uriy Prokopiev (Novosibirsk State University, Novosibirsk, Russia)

On 26 September 1996 the Russian Express-2 telecommunication spacecraft was launched and put into geostationary orbit. A Cosmic Dust/Space Debris detector was included as a piggyback instrument in addition to the ordinary transponder payload. The instrument consists of a 0.1 m^2 aperture impact plasma type detector and associated electronics and is essentially identical to the Dust instruments presently flying on the Ulysses and Galileo spacecraft. The extracted parameters include particle mass, particle velocity and flight direction.The major objectives of the experiment are to,

- Monitor the Meteoroid flux at 1 AU heliocentric distance and its dependence on solar longitude (season) and its long term variation.
- Investigate the low particle mass region of the meteor streams and its relation to the positions of the parent bodies.
- Act as a third point for simultaneous measurements with the corresponding Ulysses (out of the ecliptic) and Galileo (at Jupiter) instruments.
- Monitor the Debris environment in the Geostationary orbit and its dependence on season, launches and satellite activities and its long term variation.

The latest results from the instrument will be presented and its implications discussed.

A 1 MA PRE-EXPOSURE TO COSMIC RAYS OF A LARGE CHONDRULE IN THE H6 CHONDRITE ALH76008: EVIDENCE FOR A NEBULAR ORIGIN ?

E. Polnau and O. Eugster (Physikalisches Institut, University of Bern, CH-3012 Bern, Switzerland)
U. Krähenbühl (Anorganisch chemisches Institut, University of Bern, CH-3012 Bern, Switzerland)
K. Marti (University of California at San Diego, La Jolla CA 92093-0317, USA)

We present noble gas and chemical data of bulk material, several mineral separates, and a large chondrule from the H6-chondrite ALH76008. The diameter of the chondrule is about 3mm and its weight is 13mg. The bulk matrix material was separated into a Fe,Ni fraction and magnetic and non-magnetic silicates. These silicates were further separated into material above and below a density of 2.9g/cm^3. The objective of this work is the study of the cosmic-ray exposure history of these chondrite constituents. For the chondrule we observe an about 1 Ma higher exposure age compared to the matrix samples. We interpret this result as evidence for an exposure of the chondrule during 1 Ma before it was incorporated into the matrix of the chondritic material. Hence, the most probable scenario for the origin of this chondrule is formation in the nebula and not on the surface of a large body.

NUMERICAL EVALUATION OF LABORATORY NIR REFLECTANCE SPECTRA OF THE TWO SNC METEORITES ZAGAMI AND NAKHLA

U. Schade and R. Wäsch (DLR, Institut für Planetenerkundung, Rudower Chaussee 5, 12 489 Berlin, Germany)

Zagami and Nakhla are achondrites and belong to the SNC meteorite group. It is generally accepted that Mars is their putative body. Mineralogical and chemical analyses have revealed that the major crystallized phases of these two meteorites are pyroxenes (pigeonite, augite), olivine, maskelynite, and plagioclase. In this work laboratory NIR reflectance spectra of sawed meteorite surfaces are investigated. On this base, the characteristic absorption bands of some major mineral phases are numerically evaluated in terms of the Modified Gaussian Modell (MGM) and spectra with overlapping absorption features are resolved into the basic absorption bands. The measured spectra of the clinopxroxene phases are evaluated in respect to their Ca/Fe-ratio and it is estimated which kind of clinopyroxene belongs to the investigate mineral assemblage. As a result the major clinopyroxene phase in Nakhla is augite whereas in Zagami both augite and pigeonite are present. By means of such a procedure laboratory infrared spectra of minerals become more informative and may help in discussing future Martian remote sensing data.

PETROPHYSICAL DATABASE OF METEORITES - APPLICATIONS IN METEORITE RESEARCH AND IN PLANETARY MISSIONS

M. Terho[1], L.J. Pesonen[1], I. Kukkonen[1] and M. Lehtinen[2]
[1]Geological Survey of Finland, P.O. Box 96, FIN-02151 Espoo, Finland.
[2]Geological Museum, FIN-00014 University of Helsinki, Finland.

We have built a data base of physical properties of meteorites. The data base contains, in addition to meteorite identifications (name, class, petrographic group, age, fall/find, etc.), values of bulk density, porosity, magnetic properties (susceptibility and its anisotropy, NRM), and some other relevant data of meteorites like the shock index and weathering state. The current status of the data base has petrophysical values of ca. 400 meteorites. The meteorites come mainly from the Finnish collections but included are data also from Swedish, Czech, Australian and American (LPI) collections as well as data of meteorites from Antarctica (NIPR) and Sahara (Univ. of Münster). The petrophysical properties have been measured at the Petrophysical and Palaeomagnetic Laboratories of the Geological Survey of Finland. This data base is linkable to another, smaller data base containing values of magnetic hysteresis parameters for 80 meteorites. The data base has several applications: (i) in classifying meteorites rapidly and without damage, (ii) in modelling magnetic and gravity fields of small bodies, (iii) in estimating the composition and physical properties of asteroids, (iv) in studying the effects of shock, metamorphism and weathering on meteorite petrophysics, (v) providing background physical data of small bodies for future space missions to asteroids, and (vi) in constraining the resolution and measuring range that instruments in these satellites must meet.

Cosmic-ray exposure ages of the Rafrueti ataxite and Fe,Ni- and silicate fractions of the Don Ujimqin and Weiyuan mesosiderites

D.Terribilini, O. Eugster and E. Polnau (Physikalisches Institut, University of Bern, Sidlerstrasse 5, 3012 Bern, Switzerland)
B. Hofmann (Naturhistorisches Museum, Bernastrasse 15, 3005 Bern, Switzerland)
D. Wang (Institute of Biochemistry, Academia Sinica, Wushan, Guangzhou 510640, P.R. of China)

The aim of this work is the determination of the cosmic ray exposure age of the type I mesosiderite Don Ujimqin (>88kg, fall Sep 7, 1995 in China), of the type III mesosiderite Weiyuan (weight unknown, found 1978 in China) and Rafrueti (18.2 Kg, found 1886 in Switzerland), an anomalous ataxite, that is not chemically related to any other meteorite class and has the lowest Ir content of all iron meteorites. For the two mesosiderites Fe,Ni fractions and silicate fractions were separated and isotopic abundances of He, Ne and Ar were measured. Noble gases in all fractions are dominated by the cosmogenic and radiogenic components. Production rates were derived assuming an average shielding using three different methods for the Fe,Ni fraction and one method for the silicate fraction. The exposure ages are 172 Ma for Don Ujimqin and 17 Ma for Weiyuan. The shielding of the sample within the Rafrueti meteoroid cannot be derived from noble gas data alone. Therefore, radionuclide analyses are planned. Adopting minimum and maximum shielding as derived from a $^{4}He/^{21}Ne$ ratio of 230 we obtain exposure ages of 5 Ma and 13 Ma, respectively. We conclude that Rafrueti shows one of the lowest exposure ages observed for iron meteorites.

INFRARED SPECTROSCOPY OF TWO SNC METEORITES: ZAGAMI AND NAKHLA

R. Wäsch and U. Schade (DLR, Institut für Planetenerkundung, Rudower Chaussee 5, 12 489 Berlin, Germany)

The Zagami and Nakhla meteorites belong to the SNC meteorite group whose putative parent body might be the planet Mars. Both meteorites represent igneous rocks and are particularly important in understanding Martian igneous rocks. Zagami is a basalt/diabase which shows intense shock effects. The dominant mineralogical constituents, also in lithologically different regions, are pigeonite, augite and maskelynite. Nakhla is a pyroxenite and mainly characterized by augite. Less abundant major phases are olivine and plagioclase and a complex mesostasis. Whereas Zagami crystallized apparently on or near the surface of its parent body Nakhla seems to be a product of somewhat deeper regions. Nevertheless, both meteorites represent possible primary Martian crustal rocks. Infrared spectroscopic measurements should demonstrate the mineralogical and lithological communities and/or differences of these two rock types. On this way, the presented measurements can serve as a bridge between laboratory analyses and remote sensing of (e.g.) primary crustal terrains on Mars.

PS11 Jupiter and its satellites: results from the GALILEO mission

Convener: Neukum, G.
Co-Convener: Johnson, T.V.

SILICON IN THE EARTH'S CORE AND SULFUR IN THE CORE OF MARS.

H. Wänke and G. Dreibus (MPI für Chemie, Saarstr. 23, D-55122 Mainz)

An updated version of the Mg/Si vs. Al/Si diagram used by us previously reveals that the data points of primitive rocks from Earth and Mars plot along two individual fractionation lines. The data point for the Viking soil fits nicely to the Mars fractionation line defined by SNC-meteorites, supplying new and additional evidence for the proposition that SNC-meteorites are indeed Martian surface rocks ejected and delivered to Earth by large impacts.
Relative to the Mars fractionation line the terrestrial line is shifted to higher Mg/Si and higher Al/Si ratios indicating depletion of Si in the Earth's mantle relative to the Martian mantle. The most straightforward explanation for the depletion of Si in the Earth's mantle is that part of the Si entered the Earth's core in metallic form (Wänke, 1981). Metallic Si in the Earth's core in order to reduce both melting point and density was proposed by Ringwood (1958, 1959) and MacDonald and Knopoff (1958). Later on Ringwood (1977) abandoned this model and proposed O as the light element in the core. Recent experiments by Boehler (1996) made the presence of oxygen in the Earth's core unlikely.
We have previously shown that it is possible to build an Earth with strictly C1 abundances if one puts 12.5% of Si into the core. In our new model we only assume that Earth and Mars formed from identical building blocks but with different abundance ratios of the reduced refractory component A and the oxidized volatile elements containing component B. In this way we obtain an Earth core with 14.4% Si and a Martian core with an almost identical abundance of sulfur as the major melting point reducing elements.

LITHIFICATED REMAINS OF MICROORGANISMS IN CARBON CHONDRITES.

S.I.Zhmur (Institute of Lithosphere, RAS, Staromonetny per., 22, Moscow, 109180, Russia,Paleontological Institute, RAS)
A.Yu.Rozanov (Paleontological Institute, RAS, Profsoyuznaya, 123, Moscow, 117647, Russia)
V.M.Gorlenko (Institute of Microbiological, RAS, pr. 60-letiya Oktyabrya 7/2, Moscow, 117811, Russia)

In mineral matrix Murchison and Efremovka carbon chondrites study by means scanning electronic microscope remains of laminated and coccoid types cyanobacteries were discovered. They are similar to ones, forming Precambrian, Phanerozoic and modern cyanobacteria mats. The similarity is not only in morphology of remains, but also in the size of them. Remains of microorganisms like micromycetes were found too. One can draw a conclusion about biogenic nature of carbon substance of meteorites under study and also make an assumption about the possibility of functioning these communities on our planet from the moment of its formation and about existance of an ancient life on out of earth objects.

GRAVITATIONAL CONSTRAINTS ON THE INTERNAL STRUCTURE OF THE GALILEAN SATELLITES

J. D. Anderson, E. L. Lau and W. L. Sjogren (Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California 91109–8099, USA)
G. Schubert and W. B. Moore (Department of Earth and Space Sciences, Institute of Geophysics and Planetary Physics, University of California, Los Angeles, California 90095–1567, USA)

Before the arrival of the Galileo spacecraft in the jovian system, there was little information on the interior structure of Jupiter's four Galilean satellites. Mean densities, determined by the Pioneer and Voyager spacecraft, suggest that the two inner satellites, Io and Europa, are mostly rock, while the two outer satellites, Ganymede and Callisto, consist of rock and ice. By means of radio Doppler data, we report measurements of the satellites' spherical harmonics, J_2 and C_{22}, for their respective gravitational fields. These data show clearly that Io has a large metallic core, that Ganymede has differentiated into a core and mantle, and that Callisto is homogeneous. Results for Europa are not yet available, but they will be reported at the meeting. Combined with the Galileo discovery of a substantial magnetic field for Ganymede, our results suggest that both Io and Ganymede have metallic cores containing iron and probably an iron sulfide alloy. We find that Ganymede and Io could be essentially identical, except that Ganymede, unlike Io, has an outer layer of ice approximately 800 km thick. On the other hand, it seems that Callisto, most likely because of its more remote orbital location from Jupiter, is a pristine solar-system body that has not experienced the heating phases evident for Io and Ganymede.

GALILEO PROBE MEASUREMENTS OF THE DEEP ZONAL WINDS OF JUPITER

D.H. Atkinson (Department of Planetary Sciences, Lunar and Planetary Laboratory, University of Arizona, Tucson, Arizona, USA)

On 7 December 1995 the Galileo probe entered into and descended through the upper atmosphere of Jupiter. Throughout its descent the probe telemetered science data to the Galileo orbiter. String A of the dual string probe telemetry was driven by an ultrastable oscillator (USO). Orbiter measurements of the probe telemetry frequency provided an accurate measurement of the string A Doppler frequency residuals. Inversion of the Doppler residuals provided a vertical profile of the zonal (east-west) winds at the probe location. Recently completed analyses of the Doppler data, including corrections for timing errors in the frequency data collection, improved measurements of the probe descent velocity by the Atmospheric Structure Instrument, and corrections to the probe USO frequency drift rate for the high temperatures encountered at depth, will be discussed.

NIMS OBSERVATIONS OF THE JOVIAN SYSTEM, WITH EMPHASIS ON IO AND EUROPA RESULTS

R.W. Carlson and the NIMS Science Team (Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109)

During the last half of 1996 the Galileo Near Infrared Mapping Spectrometer (NIMS) observed Jupiter, the four Galilean satellites, and the Jovian ring in the spectral region 0.7 - 5.2 microns. These and forthcoming 1997 measurements will be highlighted, and results for Io and Europa will be discussed in detail. Io was found to have more than a dozen active volcanic regions, some of which were previously identified by either Voyager or ground-based measurements, while five of these are apparently newly active hotspots. Malik Patera showed an increase of about 400 K between the first and second Galileo orbits, separated by two months. Temperatures of the hotspots range from 210 K to 830 K, with projected areas of approximately 10 to 40,000 square km. Europa shows several distinct spectral units - all containing combinations of water ice frost and hydrated minerals, as yet unidentified. The surface showed anisotropic backscattering, similiar to terrestrial snow.

GALILEO PLASMA WAVE OBSERVATIONS AT IO REVEALING IOGENIC HYDROGEN

T. Chust, A. Roux and S. Perraut (Centre d'études des Environnements Terrestre et Planétaires, Centre National de la Recherche Scientifique et Université de Versailles-Saint-Quentin, F-78140 Vélizy, France)
D. A. Gurnett (Departement of Physics and Astronomy, University of Iowa, Iowa city, IA 52242, U.S.A.)

The Galileo plasma wave instrument has detected electromagnetic wave emissions close to second and fourth harmonics of the local proton gyrofrequency during the close flyby of Io on 7 December 1995. These emissions are likely to be generated locally, strongly suggesting the existence of pick-up protons and consequently the existence of iogenic hydrogen. Many electromagnetic wave-particle instabilities driven by a proton ring-beam distribution seem possible candidates to explain the observations. However, the fact that the jovian corotating plasma speed is sub-Alfvénic relative to Io brings severe theoretical constraints.

THE CLOUDS OF JUPITER:PRELIMINARY RESULTS OF GALILEO/NIMS FEATURE CAMPAIGNS THROUGH THE FIRST SIX ORBITS

K. H. Baines (CalTech/JPL), R. W. Carlson (CalTech,JPL), Glenn S. Orton (CalTech/JPL)

Multi-spectral, multi-phase-angle, high-spatial-resolulution (350-800 km/pixel) near-infrared imagery acquired by Galileo/NIMS are used to constrain the vertical aerosol structure within several disparate Jovian regions observed during the first six orbital encounters. These include: (1) the Great Red Spot (GRS), scrutinized at 4 phase angles (5, 25, 41, and 91 degrees); (2) portions of the Equatorial Region, the South Equatorial Belt, and South Tropical Zone, each imaged at 3 phase angles; (3) a 30-degree longitude wide portion of the North Equatorial Belt hot-spot region, scheduled for late 1996 at six phase angles - including high phase at 148 and 160 degs, and (4), White Oval BC near 33 deg S.lat (planetographic) scheduled for detailed examination over 8 phase angles - including high phase at 124, 140, and 150 degs - in Feb, 1996. Preliminary results indicate the GRS anticyclone is characterized by a spiral structure, with cloudtops descending by ~ 4 km in altitude in a counter-clockwise rotation from the 280 mbar level (28 km alt) on the eastern limb, to 320 mbar (26.5 km alt) on the western limb, to 350 mbar (24-km alt) on the southern limb.

CRATERING AND PITS ON EUROPA: INSIGHTS FROM GALILEO

Clark R. Chapman, W. Merline, B. Bierhaus, J. Keller, S. Brooks (Southwest Research Inst., #426, 1050 Walnut, Boulder CO 80302 USA)
J. Head, R. Pappalardo (D. Geol. Sci., Brown U., Providence RI 02912 USA)

Craters and pits in medium-resolution images of Europa obtained early in the Galileo orbital mission show that Europa's surface is relatively very youthful. There is a spatially non-uniform population of pits (first seen by Voyager and hundreds seen in Galileo's G1 orbit images), having diameters within a factor of 2 of 8 km. The mono-modal size distribution and a spatial avoidance of pits and lineaments imply that most pits are of endogenic origin (e.g. collapse pits). A C3-orbit image centered on wedge-like features (with 0.4 km resolution) shows only two impact craters >2 km diameter in a 50,000 sq. km region. Unless this region is very anomalous, the two craters cannot be due to a plausible projectile population that would have produced the pits seen in G1 images, again implying that the pits are not impact craters. If the relatively youthful Uruk Sulcus region on Ganymede dates from after a heavy early bombardment period, then the nearly 2-orders-of-magnitude fewer craters in the wedge image implies a crater retention age younger than 30 m.y. Despite major uncertainties in the size-distribution and impact flux history of impactors that make 2 km size craters, Europa's surface is clearly very young and resurfacing is probably an ongoing process.

INTERACTION OF IO'S ATMOSPHERE WITH JUPITER'S MAGNETOSPHERE: A 3D MULTISCALE MHD SIMULATION

M.R. Combi, T.I. Gombosi, D.L. DeZeeuw, K.G. Powell and K.S. Kabin (The University of Michigan, Ann Arbor, USA)

The results of our 3D multiscale MHD model describing the interaction of Jupiter's magnetosphere with Io's upper atmosphere and exosphere are presented. The effects of a conducting ionosphere, exospheric mass loading and a possible intrinsic magnetic field are taken into consideration. The equations of ideal magnetohydrodynamics are solved using a modern shock-capturing numerical technique. This method is applied on an adaptively refined unstructured grid. The combination of the adaptive refinement with the MUSCL-scheme allows detailed modeling of the near Io region, while still resolving both the upstream region and the satellite's wake.

Galileo-SSI Color Observations of Ganymede and Callisto

T. Denk1, G. Neukum1, R. Jaumann1, J.W. Head2, R.T. Pappalardo2, P. Geissler3, R. Greeley4, K.C. Bender4, and the Galileo Imaging Team (1DLR, Institute of Planetary Exploration, Berlin, Germany; 2Brown University, Providence, RI; 3LPL, Tucson, AZ; 4ASU, Tempe, AZ)

During the first three satellite encounters in the Jovian system, the SSI camera onboard the Galileo spacecraft obtained color images of Ganymede and Callisto with a resolution of 13 km/pxl (Ganymede/ Galileo Regio hemisphere, 6 colors), 230 m/pxl (dark-floor crater on Ganymede, 4 colors), and 10 km/pxl (Callisto/Asgard hemisphere, 5 colors). These images will be used primarily to investigate the distribution of different color or material units on the surfaces of these bodies, to find possible end-member materials, and to determine similarities and differences between the dark material on Ganymede and Callisto.

The analysis of the spectral data indicates that, besides the ice, there is just one kind of dark material on Ganymede, but Callisto seems to be covered by at least two different types. The spectrum of one of these materials shows a positive slope between 0.4 and 1.0 microns. The other reveals indications of a shallow absorption feature close to 0.9 microns and a shallower slope at short wavelengths. On Ganymede, there is a global, latitude dependent spectral signature seen in color ratio images at short wavelengths, but not when using longer wavelength color ratio images. It is possible that thermal or magnetospheric effects, or both, might account for this phenomenon. On Callisto, no comparable structure has been found. The dark floor of a crater within Ganymede's Uruk Sulcus shows a SSI spectrum similar to the dark terrain on Ganymede.

JUPITER'S IONOSPHERE: A REVIEW OF GALILEO RADIO-OCCULTATION MEASUREMENTS

F. M. Flasar (NASA/GSFC, Greenbelt, MD 20771 USA)
D. P. Hinson (Stanford University, Stanford, CA 94305 USA)
A. J. Kliore (JPL, Pasadena, CA 91109 USA)
P. J. Schinder (NASA/GSFC, Greenbelt, MD 20771 USA and Cornell University, Ithaca, NY 14853 USA)
J. D. Twicken (Stanford University, Stanford, CA 94305 USA)
R. Woo, R. Herrera, S. Asmar, D. Chong, and P. Priest (JPL, Pasadena, CA 91109 USA)

We present results of the radio-occultation measurements obtained during the first four occultations of Galileo by Jupiter. These indicate an ionosphere that is very heteorogeneous. The topmost, main electron density peaks are situated in altitude (above the 1-bar level) from $\sim$ 900 km to $\sim$ 2000 km, with widths ranging from $\sim 10^2$ to 10^3 km, and peak intensities from 10^4 to 10^5 cm^{-3}. In some cases the topside decay of the electron density is well described by a single decay scale. In others the topside behavior exhibits a multimodal structure, with a plateau in electron density persisting to 6000 km altitude. In at least one of the occultations, thin, distinct electron layers above 600 km are located below the main peak, and these may be forced by upwardly propagating gravity waves. In some other cases there is the suggestion of more complicated structure below 500 km altitude, which may indicate complex hydrocarbon ion layering below the CH_4 homopause. As of this writing, occultations of Io's torus ribbon are planned, and, if successful, results will be presented.

EUROPA: INITIAL GALILEO IMAGING RESULTS

R. Greeley[1], R. Sullivan[1], K. Bender[1], M. Belton[2], M. Carr[3], J. Head[4], G. Neukum[5], C. Chapman[6], R. Pappalardo[4], P. Geissler[7], T. Denk[5], T. Johnson[8], and the SSI Team

[1]Arizona State Univ., Box 871404, Tempe, AZ 85287; [2]NOAO, Tucson, AZ; [3]USGS, Menlo Park, CA; [4]Brown Univ., Providence, RI; [5]DLR, Berlin, Germany; [6]Southwest Research Inst., Boulder, CO; [7]LPL, Univ. of Arizona, Tucson, AZ; [8]JPL, Pasadena, CA

New data for Europa were obtained on the first three orbits around Jupiter by the Galileo spacecraft. Although data were obtained as "far encounters," some are higher resolution than the Voyager data by a factor of 5. Analyses show intricate patterns of cross-cutting ridges, disrupted terrain in which the icy crust appears to have been separated and repositioned, newly discovered large (~30 km) impact craters, large expanses devoid of craters >1 km (limits of detection), and details on the nature of surface features such as triple bands (e.g., diffuse outer margins), narrow ridges which include central depressions, and a possible correlation between decreasing ridge height and time. New color data reveal subdivisions of bright plains and suggest genetic relationships among some surface features. Geometric relationships enable sequences of formation to be derived. These and other observations suggest the following: 1) a variety of surface ages, including geologically-recent materials, 2) recent tectonic disruption in the anti-jovian hemisphere which could be attributed to relatively shallow (<30 km) convection, 3) cryovolcanic processes involving volatile-driven venting and extrusion of ductile ice, 4) possible viscous relaxation of small scale features (<1-2 km), suggesting near surface heating. Data with 40 times better resolution will be obtained on subsequent orbits, and will enable testing of these and other interpretations.

HIGH ENERGY CHARGED PARTICLES IN THE INNERMOST JOVIAN MAGNETOSPHERE

H. Fischer, E. Pehlke and S. Sievers (Institut für Kernphysik, Universität Kiel, D-24118 Kiel,Germany)
L. J. Lanzerotti (Bell Laboratories, Lucent Technologies, Murray Hill, N.J.07974-2070, USA)
J. D. Mihalov (NASA-AMES Research Center, Moffet Field, Ca. 94035-1000, USA)

The Energetic Particle Investigation (EPI) experiment was carried by the Galileo Probe into the innermost part of Jovian magnetosphere on December 7, 1995. The instrument acquired 15 data samples containing measurements of the energy and angular distributions of the high energy particle populations from near the orbit of Io to Probe entry into the Jovian atmosphere. The magnetosphere region inside $\approx$ 2 Jovian radii (R_J) from the planet's center had not yet been explored by any spacecraft. Prominent findings of the mission include a new zone of Jupiter's inner radiation region with extremely high rates of energetic electrons and protons peaking in intensity at $\approx$ 2.2 R_J, the absorption of the measured particles in the vicinity of the outer edge of the bright dust ring, and the discovery of intense fluxes of high energy ($\approx$62 MeV/nucl) helium ions peaking in intensity at $\approx 1.5R_J$, inside the bright dust ring. A very steep decrease for all particle species found at $\approx 1.35R_J$ defines the innermost edge of the equatorial Jovian radiation.

THE TOPOGRAPHY OF GANYMEDE : STEREO ANALYSIS OF GALILEO SSI IMAGES

B. Giese, J. Oberst, T. Roatsch, G. Neukum (DLR - Institute of Planetary Exploration, Rudower Chaussee 5, 12489 Berlin, Germany)
J. Head, R. Pappalardo (Brown University, Providence, RI 02912)
and the Galileo imaging team

The Galileo SSI camera acquired high resolution (< 100m/pixel) stereo images in Ganymede's Galileo Regio and Uruk Sulcus area during the encounters in June (G1) and September (G2) 1996. The images were taken at similar solar illumination and from camera positions separated enough for good stereo conditions. We performed a photogrammetric analysis of these image data and derived Digital Terrain Models and orthophotos (rectified images). The obtained terrain models cover an area of 22km x 30km (Uruk Sulcus) and 63km x 102 km (Galileo Regio), and have spatial resolutions of 200m/pixel and 300m/pixel, respectively. The resolution is by a factor of three poorer than the resolution of the images, due to limitations of the digital image correlation approach. We used patch sizes (correlation windows) of 15 pixels to cope with strong compression artifacts in the G2-images. Both terrain models have similar characteristic height ranges on the order of 1km. Heights are relative heights only because ground control information was not available. The Uruk Sulcus terrain shows distinct large-scale grooves and ridges aligned with visible dark and bright surface lineaments. This strong correlation of elevation with material brightness may hold information on the processes that have formed this terrain type and needs to be further explored.

GALILEO PLASMA WAVE OBSERVATIONS AT JUPITER

D. A. Gurnett, W. S. Kurth (Department of Physics and Astronomy, University of Iowa, Iowa City, IA 52242, USA) A. Roux, S. Perraut, and T.Chust (CETP, 10/12 Av. de l'Europe, 78140 Velizy, France),e-mail: alain.roux@cetp.ipsl.fr P. Louarn (Observatoire Midi-Pyrenees, 14 Av. E. Belin, 31320, Toulouse) S. J. Bolton (Jet Propulsion Laboratory, Pasadena, CA 91109) C. F. Kennel (UCLA, Los Angeles, CA 90095)

This paper gives an overview of results from the Galileo plasma wave instrument at Jupiter. During the inbound pass, electron densities were obtained through the Io torus from narrowband emissions at the upper hybridresonance frequency. These densities are about twice as large as thoseobtained during the Voyager 1 flyby in 1979. A well-defined peak occurred in the vicinity of Io with densities as high as 4 x 10^4. The partial occultation of Jovian hectometric emissions is used to give evidence for an assymetric cloud of dense and cool plasma in the centralpart of the Io wake. During the few tens of minutes, corresponding to the Io closest approach,two types of low frequency fluctuations are superimposed on a background of Whistler mode emissions. We discuss possible interpretations and thier consequences in term of acceleration in the vicinity of Io. During the Ganymede 1 flyby, the plasma wave instrument detected a number of unexpected plasma wave phenomena, many of them similar to those observed in a planetary magnetosphere. These include whistler-mode chorus, (n+1/2)f_c electron cyclotron emissions, upper hybrid emissions, broadband bursts of electrostatic noise on the inbound and outbound legs at what appears to be either shock or magnetopause crossings, and escaping high-frequency radio emissions. The upper hybrid emissions indicate that the spacecraft passed through a dense plasma near closest approach with peak electron densities of about 45 cm^-3.

GANYMEDE: ORIGIN AND EVOLUTION OF BRIGHT TERRAIN FROM GALILEO RESULTS

J. W. Head (Dept. Geol. Scis., Brown Univ., Providence, RI 02912 USA), R. Pappalardo and G. Collins (Brown Univ.), D. Senske (JPL, Pasadena, CA), G. Neukum, B. Giese, J. Oberst, H. Hiesinger, A. C. Cook, B. Schreiner and U. Wolf (DLR, Berlin, Germany) and The Galileo Imaging Team.

Galileo results from the first two encounters of Ganymede provide important new information about bright terrain and the processes that have formed and modified it. Individual grooves seen in Voyager data are each characterized by a very high abundance of parallel fractures spaced several hundred meters apart which appear to represent tilted fault blocks; youngest groove sets have erased preexisting groove sets through "tectonic resurfacing" and there is evidence for changes in tectonic style with time from graben formation to domino-style tilt blocks. Where clearly observed, 'T-intersections' are due to tectonic crosscutting of older terrain by the top of the T. Geologic units are distinguished and mapped on the basis of stratigraphic relations and crater size-frequency distributions. Comparison of domain structural trends shows evidence for integrated regional patterns of extensional deformation and some shear. Evidence for cryovolcanism is seen only locally. Using Voyager data the tectonic patterns observed in the Galileo coverage can be extended to broader surrounding regions; these provide regional tectonic syntheses and information on the inferred change in orientation of stress as a function of time. This provides insight into the breakup of the dark terrain and how bright terrain is formed and modified. At the other end of the scale range, very high resolution data (~11 m/pixel) reveal detailed mass wasting characteristics of individual massifs.

GANYMEDE: DARK TERRAIN CHARACTERIZATION AND EVOLUTION FROM GALILEO RESULTS

J. W. Head (Dept. Geol. Scis., Brown Univ., Providence, RI 02912 USA), L. Prockter & R. Pappalardo (Brown Univ.), P. Helfenstein (Cornell Univ., Ithaca, NY), G. Neukum, B. Giese, J. Oberst, H. Hiesinger, A. C. Cook, B. Schreiner & U. Wolf (DLR, Berlin, Germany), D. Senske (JPL) and The Galileo Imaging Team

Initial Galileo encounters targeted dark terrain (comprising about one-half the satellite and interpreted to be a nearly-primordial impact-generated surface) in several areas to image furrow sets, impact craters, dark plains, palimpsests, dark-bright terrain relationships, to obtain stereo, and to provide comparisons with Callisto. Detailed mapping of Galileo Regio and Marius Regio at high resolution shows that dark terrain has a very heterogeneous albedo; bright material is exposed on massifs and abundant knobs (old crater rims) and on the slopes of crater walls and furrows; steep slopes in dark terrain often show streamers of dark material suggestive of erosional debris being shed off slopes and revealing brighter ice deposits just below the dark veneer. Initial Ganymede data show evidence for a very old regional fabric of deformation revealed as impact crater wall structure. Details of furrow rim structure illustrate relationships between furrows and impact craters and provide evidence for stratigraphic sequence. Topography data of furrows in Galileo Regio provide further information about sequence and show that topographic prominence decreases with increasing age. Dark plains, some with embayment relations and locally sharp flow-like contacts with adjacent terrain, occur preferentially in lows adjacent to ridges, massifs and crater rims; bright plains occur in a large old impact crater and within several palimpsests; palimpsest interiors appear extremely knobby, reminiscent of fresh lunar crater floors. Crater size-frequency distribution data show that Galileo Regio surfaces overlap in age with the oldest bright terrain. Documentation of modes of occurrence of dark terrain deposits is providing evidence for darkening agent sources and processes of evolution, and a basis for comparison with Callisto.

GALILEO AT JUPITER: STATUS AND OVERVIEW

T. V. Johnson (Jet Propulsion Laboratory, Caltech, Pasadena, CA, USA)

The Galileo Orbiter spacecraft has been in Jupiter orbit since 7 December, 1995. During its continuing orbital tour Galileo is sending back a continuous stream of data about Jupiter, its magnetosphere and the Galilean satellites. Results to date include the discovery of a dense, cold high altitude plasma and strong field aligned current systems at Io, a dense core for Io, a dense core for Ganymede coupled with a magnetic field which creates a magnetosphere around this icy moon, evidence for tectonic resurfacing of portions of Ganymede, unexpected mass wasting on Callisto, and measurements of aurora on Jupiter and in Io's patchy tenuous atmosphere. The current status of the mission and plans for the final portion of the nominal mission and possible extended operations will be discussed.

This work was done at the Jet Propulsion Laboratory, Caltech under a contract with NASA.

MAGNETIC FIELD OBSERVATIONS AT JUPITER: MAGNETOSPHERIC DYNAMICS AND MAGNETIC SIGNATURES OF THE GALILEAN MOONS

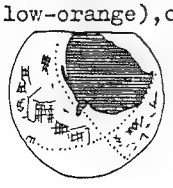
M. G. Kivelson (IGPP, UCLA, Los Angeles, CA 90024-2567, USA), K. K. Khurana, C. T. Russell, R. J. Walker, and D. J. Southwood

The Magnetometer Investigation on the Galileo spacecraft has acquired high time resolution data during limited intervals of the orbital tour, including times near the close passes of all four Galilean moons. These data enable us to describe the magnetic environment of the moons and to draw inferences regarding their internal structure. We will also present some evidence for interchange transport within the Io plasma torus. In addition to the limited high time resolution measurements, low time resolution data were acquired during many months of orbital cruise. Extended portions of the cruise data appear well organized and quite predictable. These data provide an overview of the magnetospheric structure in the present epoch. In other intervals, field variability suggests either significant time-dependent changes or encounters with spatial boundaries. We will consider the different interpretations.

GALILEO REGIO IN GANYMEDE'S SECTORAL STRUCTURE

G.G.Kochemasov,IGEM,Russian Academy of Sciences

At the 24th Vernadsky-Brown symp.we showed Ganymede's global Voyager image built of 4 sectors (Fig.).The largest polygon of dark cratered terrain-Galileo Regio is one of 4 sectors in a regular hemispheric structure of dark,bright & 2 separating them grooved terrain sectors.2 last ones are considered as "neutral breccia" of two extreme(dark-bright)types of crust.Similar sectoring is typical for crusts of many cosmic bodies/Kochemasov,91-96/.A global Galileo image of Ganymede in spectral ratios(false colours), presented by J.Head,confirms this sectoral structurization.Under some colour haze are distinguished Galileo Regio in yellow(green-yellow,yellow-orange),opposite to it bright sector in blue, blue-violet with orange spots & separating them sectors as green with blueish spots & green-yellowish. These hues testify compositional changes & rather sharp sectors limits.Dark sector and fragments most probably are subsided terrains.



GALILEO DUST MEASUREMENTS DURING JUPITER SATELLITE FLYBYS

Harald Krüger and Eberhard Grün (Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany)
and the Galileo and Ulysses Dust Teams ()

Since December 1995 continuous dust measurements in the Jovian system were obtained with the Dust Detector System (DDS) onboard the Galileo spacecraft. The dust impact rate varied by about 4 orders of magnitude during the orbit tour. The highest impact rates of more than 10 impacts per minute were detected inside 30R_J from Jupiter. These high dust impact rates are comparable to the values found by Galileo in interplanetary space during the strongest observed dust storms.

Inside 50R_J the impact rate fluctuates by up to a factor of several hundred with a period of about ten hours. This is compatible with Jupiter's rotation period and implies that we see charged submicron-sized dust particles and their motion is strongly affected by the planet's magnetic field.

In addition to the periodic structure, a strong peak occurred at the closest approaches during the Ganymede flybys. Here we may see ejecta kicked up by impacts of micrometeoriods on the satellite's surface.

A change in the impact direction of the dust grains by 180 degrees occurred about one day before both Ganymede closest approaches and about half a day after Callisto closest approach, respectively. In all three cases this happened at about 20 to 25R_J from Jupiter.

ANALYSIS OF GALILEO NIMS REFLECTANCE SPECTRA FOR THE ICY GALILEAN SATELLITES

T.B. McCord, G. Hansen, C. Hibbitts, F. Fanale, J. Granahan (Hawaii Inst. Geophys. & Planet., U. Hawaii, Honolulu, HI 96822), R.M. Clark (USGS-Denver), R.W.Carlson, W. Smythe, M. Segura (Jet Propulsion Lab.), and the NIMS Team.

We present analysis of NIMS reflectance spectra for the icy Galilean Satellites and specifically the interpretation of these spectra to determine the presence and identity of any non-ice components of the surface. Spectra have been analyzed so far for regions on Callisto, Ganymede and Europa, and more spectra are expected for all three icy satellites before this report is given. NIMS is providing up to 408-channel spectra over the spectral range 0.7 to 5.2 μm for spatial resolution elements varying from near 1 km to hundreds of kms. Analysis reveals high-quality spectra exhibiting the presence of ice and non-ice spectral features, many not seen so far in groundbased telescopic data. These include a weak absorptions near 3.87, 4.03, 4.25 and 4.57 μm. These bands vary in strength with location in an uncorrelated way suggesting that a number of different materials are responsible. Candidate materials so far identified for the 4.25 μm absorption include hydrated minerals exhibiting various metal-OH -- OH or HOH combination bands or CO2, probably in a clathrate, with amounts modeled to be 0.5 wt% CO2 on Callisto and 0.2 wt% CO2 on Ganymede, on the average. Some of these bands appear more weakly on Ganymede. Spatial distributions include a concentration of the 4.25 μm band near the equator on Ganymede and in crater ejecta. Fine grained frost is concentrated near the poles on both Ganymede and Callisto and masks some of the absorption.

CRATER SIZE-FREQUENCY DISTRIBUTIONS ON EUROPA, GANYMEDE AND CALLISTO: RESULTS FROM GALILEO SSI HIGH-RESOLUTION IMAGES

G. Neukum, R. Wagner, U. Wolf (DLR, Institute of Planetary Exploration, D-12489 Berlin, Rudower Chaussee 5, Germany), J. Head III, B. Pappalardo (Brown University, Providence/RI, USA), and the Galileo Imaging Team

The first close flybys of the Galileo spacecraft at the Galilean satellites Ganymede (orbits G1, G2), Callisto (C3) and Europa (E4) and the return of images about 15 times higher in spatial resolution than Voyager images provide new insights into relative abundances of impact craters and ages of geologic units on these bodies. Measurements can be extended down to craters with diameters of 50 m. Crater size-frequency distributions on Ganymede and Callisto can be approximated by the lunar production function, transformed to the different impact conditions on these satellites. On Ganymede, crater densities between average dark and bright terrains differ by about a factor of 10. Assuming a lunar-like flux of projectiles at the end of the heavy bombardement, age differences are about 300-500 m.y. for these terrain types. Only a small number of craters has been found on Voyager images from Europa. During its first close Europa flyby (E4) in Dec. 1996, Galileo will return images with a ground resolution down to 26 m/pxl.

GALILEO DUST MEASUREMENTS DURING THE JOURNEY TO JUPITER

Rainer Riemann and Eberhard Grün (Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany)
and the Galileo and Ulysses Dust Teams ()

The Galileo spacecraft is equipped with an impact ionisation dust detector with 0.1 m sensitive area, which is able to measure the impact of cosmic dust grains with masses between 10^{-9}kg to 10^{-19}kg. An identical detector is on board the Ulysses spacecraft.
On its 6 year journey to Jupiter Galileo cruised in the ecliptic plane between Venus and Jupiter and collected the complete data of 2778 dust impacts. This data is now available to the scientific community.
During its final approach to Jupiter, Galileo encountered 10 dust streams coming from the direction of Jupiter. Dust streams from Jupiter have previously been discovered by the Ulysses spacecraft during its Jupiter flyby in 1992. The Galileo streams have been more intense, probably due to a better viewing geometry. The average impact rate was about 1 per day during the interplanetary cruise phase, but increased up to 20000 per day during the most intense dust stream. This dust consists of very small particles at the threshold of our detector. Possible sources of this dust could be volcanic eruptions on Io or dust from the jovian ring system.

OBSERVATIONS OF IO BY GALILEO SSI

A. McEwen, L. Keszthelyi, P. Geissler (LPL, Univ. of Arizona, Tucson/AZ, USA), D. Simonelli (Cornell Univ., Ithaca/NY, USA), T. Johnson, K. Klaasen (JPL, Pasadena/CA, USA), M. Carr (USGS, Menlo Park/CA, USA), J. Oberst, G. Neukum (DLR, Berlin, Germany), M. Belton (NOAO, Tucson/AZ, USA), and the SSI team

The Galileo Solid State Imaging (SSI) experiment has produced many new results of the volcanic activity and surface and atmospheric characteristics of Io. Images acquired during the first three orbits provided global coverage in four colors; images of Io in eclipse; a global inventory of large, bright volcanic plumes; and a set of topographic mapping frames over the anti-Jove and trailing hemispheres. Early science results include the following: (1) Comparison to Voyager images acquired in 1979 reveals new volcanic deposits over ~ 15 large (100-km scale) areas. (2) Active volcanic regions are associated with both low albedo and intensely reddish surface materials, which appear to fade over time. (3) Many surface units display unusual changes in brightness as a function of phase angle, resulting in frequent contrast reversals. (4) High temperatures (> 700 K) are often present at active volcanic centers, so eruption of materials with a high melting point, such as silicates, is common. (5) Regions of extensive surface changes often do not correspond to regions of intense hot spots, suggesting that resurfacing by low-temperature materials such as sulfure may be common. (6) Visible volcanic plumes are much less common than they were in 1979. (7) Io's tenuous atmosphere, dominated by active plumes, can be seen as diffuse glows while Io is eclipsed by Jupiter. (8) The vent regions of several active plumes appear to have migrated up to 100 km since 1979. (9) Landforms such as mountains, plateaus, and calderas are ubiquitous over Io, but the topography is unusually subdued over the bright equatorial region named Colchis Regio.

The Global Shape of Io: Status of Control Point Network Analysis

J. Oberst, W. Zeitler, P. Schuster, A. Hoffmeister, G. Neukum (DLR - Institut of Planetary Exploration, Rudower Chaussee 5, 12489 Berlin, Germany)
M. Davies, T. Colvin (Rand Coporation, USA)
P. Thomas (Cornell University, USA)
A. McEwen (LPL, Tucson, USA)
and the Galileo Imaging Team

In August 1996, Galileo SSI obtained a series of 31 global images of Io at resolutions from 13.4 to 30.6 km/pixel. These CCD images are superior in their geometrical precision to the Vidicon images obtained by Voyager, and unique in its uniform coverage of Io. They therefore provide the opportunity to study the global shape of Io. We selected and determined image coordinates of 120 control points in the images, and thus carried out a total of 1638 line/sample measurements. In a bundle block adjustment, we adjusted camera pointing and spacecraft position data and determined the ground coordinates of these points. Resulting x-, y-, and z- coordinates have errors of 15.8, 18.8, and 7.2 km, respectively. The global shape of Io, its large-scale topography, and the relationship between topography and internal state will be discussed. This control point network will be greatly improved when new images of Io that were gathered in December 1996 and new data expected to be returned in 1997 will be included in the analysis.

Characteristics of Jovian lightning deduced from RF measurements on board the GALILEO Entry Probe

K. Rinnert (Max-Planck-Institut fur Aeronomie, Postfach 20, D-37189 Katlenburg-Lindau, Germany)
L.J Lanzerotti, Bell Laboratories, Lucent Technologies, Murray Hill, NJ 07974, USA
G. Dehmel and F.O. Gliem (Technische Universität Braunschweig, D-38106 Braunschweig, Germany)
E.P Krider (University of Arizona, Tucson, AZ 85721, USA)
M.A. Uman (University of Florida, Gainesville, FL 32611, USA)

The GALILEO Entry Probe carried a lightning and radio emission detector (LRD) instrument to characterize possible lightning in the Jovian atmosphere. The main sensor was a ferrite core antenna with a bandwidth of 100 Hz to 100 kHz. During the Probe descent 12 data sets could be obtained each covering a time interval of 256 s and consisting of spectral densities at 3, 15 and 90 kHz, statistical distributions of pulse amplitude, pulse duration and interpulse gaptime and a 1-ms window containing a selected waveform. The received signal intensity was low and the instrument operated most of the time close to its sensitivity limits. The measured spectral densities decreased with frequency and with depth, the pulse statistics also indicated that the majority of the received signals were long pulses (100 μs) compared to typical Earth lightning pulses (10 μs) Only one waveform sample could be attributed to a lightning discharge and this also shows a low frequency signal. Propagation modeling yields that that the sources are more than 10000 km away from the Probe descent. No close lightning could be detected, which is consistent with the fact that the Probe entered a dry region. All the LRD data are consistent and it is concluded that Jovian lightning is localized, respectively, not uniformly distributed, and individual discharges are more powerful and last longer than typical lightning discharges on Earth.

CORRELATION BETWEEN H_2O ABUNDANCE AND CLOUD OPACITY IN 5 μM *GALILEO/NIMS* OBSERVATIONS OF THE JOVIAN NEB

M Roos-Serote, P. Drossart, Th. Encrenaz, E. Lellouch (Observatoire de Paris-Meudon, DESPA, France)
R. W. Carlson, K. Baines (J.P.L., Pasadena, U.S.A.)

We present the analysis of *NIMS* data (HOTMAP) of the jovian North Equatorial Band (NEB), obtained in June 1996. These data consist of approximately 6000 *NIMS* spectra of a part of the NEB, with a spatial resolution of about 400 km/pixel. We concentrate on the spectral region between 4.6 and 5.3 μm where all *NIMS*-wavelengths were recorded at spectral resolution of 0.026 μm. The 5 μm continuum intensity in the HOTMAP data varies by a factor of 20 between the coldest and the hottest pixels. The spectrum is most sensitive to the cloud opacity at 1.55 bars and the water abundance between 4 and 8 bars. Using a line-by-line radiative transfer code, fits for about 1500 spectra have been obtained. A correlation is observed between the cloud opacity and the deep water abundance, *i.e.* a small cloud opacity corresponds to a small amount of water. As shown in earlier analysis (Carlson et al., Science 274, 1996), this observation is consistent with the Galileo Probe measurements. It is also consistent with a model where the hottest regions correspond to descending currents of dry jovian air, in which clouds evaporate rapidly. Future work will provide values for parameters that are needed in the exploration of these kind of models (Showman and Ingersoll B.A.A.S. 28, 1996).

Analysis of Io's Regional Topography Using Galileo Stereo Images

P. Schuster; J. Oberst; W. Zeitler; G. Neukum; (DLR - Institut of Planetary Exploration, Rudower Chaussee 5, 12489 Berlin, Germany)
A. McEwen (LPL, Tucson, Arizona, USA)
and the Galileo Imaging Team

In November 1996, Galileo SSI obtained a series of 7 clear-filter images of Io at resolutions of 4.1 - 2.5 km/pixel. These constitute the highest resolution Galileo Io images that are available. While Voyager images of higher resolutions exist, the CCD images of Galileo are superior in their geometrical precision. Several regions on Io are covered by two or three of these images from multiple viewing directions approximately 30° apart. This dataset therefore provides a unique opportunity for precise photogrammetric analysis and digital terrain modelling. In a first analysis of these images, we produced terrain models of the regions around Marduk, east of Volund, and northeast of Pele. We collected tiepoints in the images to correct the nominal camera pointing and spacecraft position data in a block adjustment. Using digital image matching, large numbers of conjugate points between image pairs were determined. These matched points were converted to object coordinates and interpolated to form DTM (Digital Terrain Model) grids at 10 km scales. Preliminary inspection of the DTM shows distinct topographic highs and lows with elevations varying by as much as +/- 2 km. The terrain data will be analyzed in detail and will be discussed with respect to geological and rheological aspects. Higher-resolution images will not be obtained before the envisioned close Io flyby in October 1999.

STRATIGRAPHY AND CRATER SIZE-FREQUENCY DISTRIBUTIONS ON CALLISTO: RESULTS FROM VOYAGER AND GALILEO SSI IMAGES

R. Wagner, G. Neukum (DLR, Institute of Planetary Exploration, D-12489 Berlin, Rudower Chaussee 5, Germany), R. Greeley, K. Bender, R. Sullivan (Arizona State University, Tempe/AZ, USA), and the Galileo Imaging Team.

At Voyager resolution, the surface of the outermost Galilean satellite Callisto shows less geologic diversity compared to its inner neighbour Ganymede, in spite of similar size and average density. Geologic units mapped are: (1) Crater materials in at least three stages of degradation, (2) crater chains, (3) bright, circular to irregular Palimpsest-like features, (4) large multi-ring basins, (5) dark materials with varying degrees of crater density, (6) smooth sparsely cratered materials. Crater densities between geologic units differ generally by factors of less than 10, up to 20. Resurfacing is quite likely to have occurred and is also confirmed by crater size-frequency measurements. Most of the geologic units on Callisto may date back prior to the end of heavy bombardement. The first close flybys of the Galileo orbiter at Callisto in 1996 show regions unseen by Voyager so far and in much higher resolution. Geologic mapping and crater size-frequency measurements may be extended down to a resolution of less than 30 m/pxl.

The Distribution of Bright and Dark Material on Ganymede in Relationship to Topography

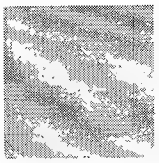
B. Schreiner, B. Giese, J. Oberst, G. Neukum (DLR - Institute of Planetary Exploration, Rudower Chaussee 5, 12489 Berlin, Germany)
J. Head, B. Pappalardo (Brown University, USA)
and the Galileo Imaging Team

Galileo's high-resolution stereo image data obtained in the Uruk Sulcus region and Galileo Regio give us the opportunity to study the areal distribution of dark and bright surface material and its relationship to surface topography. In an attempt to study importance of photometric effects in the images, we applied lambertian and lunar-lambert shading to the DTM (Digital Terrain Model) and compared this with the actual image data. This lead us to conclude that visible brightness variations are not mainly photometric but rather determined by albedo variations, i.e. by prevalence of bright and dark surface material. For a more detailed analysis, we derived orthoimages (images that are rectified based on DTM information) from each of the stereo partner images in a way that the images exactly matched the DTM in terms of map projection type and scale. From orthoimages and the DTM we selected corresponding profiles perpendicular to visible surface lineaments in order to directly compare height and brightness variations along these profiles. For Uruk Sulcus we found that long-wavelength peaks in image brightness correlate with topography. Short-wavelength lineaments are not sufficiently resolved in the terrain model. The darker material seems to have accumulated in topographic lows, whereas bright material appears to be located on higher-elevation ridges. In Galileo Regio, it appears that, in addition, bright material is preferentially located at slopes facing to the North and West.

IMAGING JUPITER FROM *GALILEO*: PRELIMINARY RESULTS ON CLOUD STRUCTURE

E. Ustinov, D. Banfield, M. Bell, P. Gierasch (Cornell University, Ithaca, NY 14853, USA), M. Belton (National Optical Astronomy Observatory, 950 North Cherry Avenue, Tucson, AZ 85719, USA), and the Galileo Imaging Team.

Sets of Galileo images have been targeted to study local regions at high resolution. To date, these regions include the Great Red Spot (GRS), belt-zone boundaries near the equator, and a region north of the equator that is similar to the Galileo Probe entry site (a 5 micron hot spot). The combination of strong methane band, weak methane band and continuum images provides information on vertical cloud structure. Deep convective clouds are observed northwest of the GRS with a vertical extent that strongly indicates water condensation. Higher-level clouds are common in all regions and are indicated to be ammonia. A haze in the lower stratosphere has subdued lateral structure sufficient to permit mapping of motions separately from the deeper ammonia cloud motions. Some features near the equator can be interpreted as the upper and middle branches of a Hadley circulation which are separately apparent at different elevations.



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